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THE

MEIGS RAILWAY.

THE REASON FOR ITS DEPARTURES FROM THE ORDINARY PRACTICE. ITS DEPARTURES, AND HOW AND WHY A SAFE RAILWAY IS POSSIBLE.

A GENERAL DESCRIPTION OF IT. A CRUCIAL DISCUSSION OF ITS MECHANICS.

ITS COMPARISON WITH THE ORDINARY SURFACE AND ELEVATED ROAD.

THE REPORT OF, AND ITS APPROVAL BY, THE STATE ENGINEER APPOINTED BY THE HONORABLE BOARD OF RAILROAD COMMISSIONERS.

A PARALLELISM BETWEEN THE MEIGS AND ORDINARY 4 FOOT 8½ INCH GAUGE RAILWAYS. THE RECITAL OF THE TESTS AT EAST CAMBRIDGE, WHICH PROVED THAT NO FATAL ACCIDENT CAN OCCUR FROM ORDINARY BREAKAGE OF RAIL OR PARTS.

By JOE V. MEIGS.

BOSTON:
C. H. WHITING, No. 168 DEVONSHIRE STREET.
1887.

74292

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THE

MEIGS ELEVATED RAILWAY COMPANY.

INCORPORATORS

Under the Act of 1884, Chapter 87.

JOE V. MEIGS,
WM. S. BUTLER,
WM. A. RUSSELL,
ROLAND WORTHINGTON,
THOS. W. PIERCE,
GEO. E. HARRINGTON,
J. W. JOHNSON,
CHAS. E. POWERS,
HENRY HASTINGS,
NATHAN APPLETON,
FRANKLIN E. GREGORY,
EDGAR E. DEANE,
GEO. A. ALDEN,
FRANK JONES,
GEO. J. CARNEY,
AND THEIR ASSOCIATES.

ITS INCORPORATING DIRECTORY.

HON. FRANK JONES,
of Portsmouth, N. H.

FRANKLIN E. GREGORY,
of Framingham, Mass.

NATHAN APPLETON,
of Boston, Mass.

CHAS. H. WHITING,
of Boston, Mass.

JOHN P. WYMAN,
of Cambridge, Mass.

JOE V. MEIGS,
of Lowell, Mass.

Office of the Meigs Elevated Railway Company, 30 Court Street, Boston, Massachusetts, United States of America.

TO THE PEOPLE: —

The following letters, recitals, and reports will explain to you the present status of my system of railway.

JOE V. MEIGS.

MEIGS ELEVATED

RAILWAY CONSTRUCTION CO.

225 BRIDGE STREET,

EAST CAMBRIDGE, MASS.

BENJ. F. BUTLER,
President.

WM. S. BUTLER,
Treasurer.

W. W. KIMBALL.

I. A. EVANS.

A. C. DRINKWATER.

S. L. SIMONDS,
Clerk.

JOE V. MEIGS,
Inventor and Manager.

JAS. L. MEIGS,
Acting and Consulting Engineer.

WORKS OF THE
MEIGS ELEVATED RAILWAY CONSTRUCTION COMPANY,
NO. 225 BRIDGE STREET, EAST CAMBRIDGE,
MASSACHUSETTS.

NOVEMBER 22, 1886.

To General George Stark, Engineer, of the Board of Massachusetts Railroad Commissioners, Hon. Thomas Russell, Chairman, Edward W. Kinsley, Everett A. Stevens, Esquires, appointed to examine the Meigs Railway, in conformity with the requirement of the Meigs Elevated Railway Company's charter:—

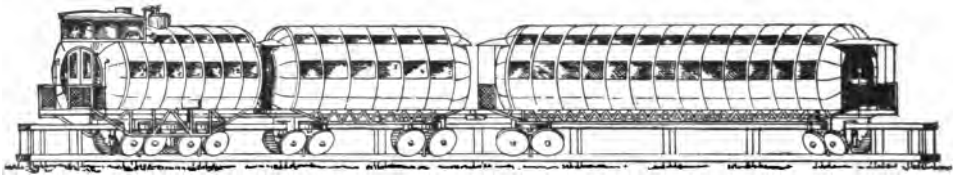
DEAR SIR,—I have made for publication as short and concise an illustrated review of the whys of my system of railway as I can, and I send it to you with the hope that it will aid you in your investigations. My brother's (James L. Meigs) figures showing the principle of the construction of our girders and their correct proportion, together with those relative to the tests of the way, I send to you, with the request that you return them after using, because they are the results of many years of labor and study, and would be of no use to publish in a review like this.

I am,

Very truly yours,

JOE V. MEIGS.

CUT NO. 1.



View of Meigs train on low post or surface way of 50-feet radius, on 120-foot grade to mile.

THE RAILWAY.

To the stockholders of the Meigs Elevated Railway Construction Company, and particularly to General Benjamin F. Butler, president; William S. Butler, treasurer; A. C. Drinkwater, W. W. Kimball, and Irving A. Evans, directors; to the legislators who aided me by their personal efforts and by their votes; to the sixty-four thousand signers of petitions to the Legislature in my favor; to the constructing mechanics, draughtsmen, tradesmen, and to personal friends who have aided me, I am greatly pleased to present a summary of the reasons why I have made my railway as I have: and to the many persons who, without reason, chose to be the bitter enemies of my road, I present the results of the successful demonstration of all that I have ever claimed, and ask their reconsideration.

THE EFFORT TO GET A LEGAL STANDING FOR THE MEIGS SYSTEM OF RAILWAY.

In the winter of 1879–80 models of my careful studies, extending through the many years from 1857 to 1879, were prepared and got ready for presentation to the Legislature, being already sufficiently fortified by patents for the then state of its existence.

ALLIANCE OF THE STREET-RAILWAYS SOUGHT.

By the advice of counsel I called together many persons interested in street-railways and sought their alliance. They

agreed that my models offered the best plan, with the least obstruction to light and air, with the greatest capability of turning crooked streets, and, for this reason, the only solution of the difficulties of street-railway traffic suitable to Boston. They agreed to join with me the next winter in making application for charter if I would not apply that winter.

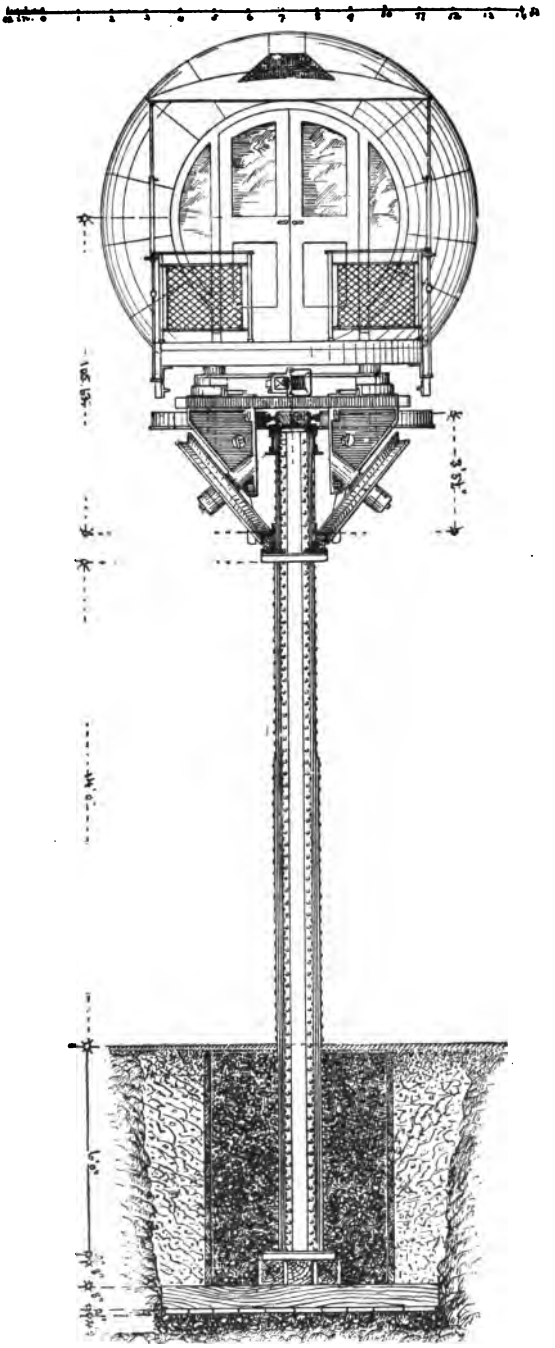
In 1880–81 I made the application, but had no aid from that source. On the contrary, they opposed me before the committees, joined by other railways, with an array of talent in the shape of some twenty lawyers; besides, they corralled many other very interested opponents of progress who were not under the pay of the already existing corporations.

I did not ask for special location, believing then, as I do now, that any community that might desire to build my railway ought to be permitted to do so.

WHAT I WANTED.

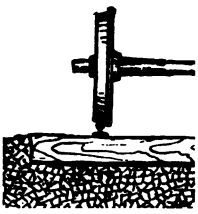
I asked to be permitted to build my railway under the laws governing the building of other systems of railway. The same method of capitalization should be now, as it should then have been, given me. The same advantages, no less, surely, because I proposed to do the same thing in a better way. The same penalties should have been imposed, and no others. I asked to be permitted to build my system of railway, instead of the system of railway ordinarily used, I using steam in exactly the same manner as they use it, my use making less noise, disturbance, and nuisance.

Railways are required by law to be built to a gauge of



Cut No. 2. — The above cut is an end representation of the car upon the track — its trucks, the post, and its setting; showing the trucks astride of the track 48 inches.

3 ft., or of 4 ft. 8½ in., their tracks being upon the surface of the earth, exposed to snows, rains, etc. I changed this with a view to the absolute safety of the passenger, so that my way was to be a compound girder twenty-two and one-half inches at its widest part, the ordinary tracks turned up on edge, as it were, and supported by posts, put in below the frosts and standing above the snow, removed from water, with the trucks astride of the way extending downward forty-eight inches, furnished with supporting-wheels and tied on by horizontal wheels to keep the cars on the track, instead of being kept on by flanges *only one inch* deep over the rail to prevent derailment at the hour of peril, as is the case of the ordinary surface and elevated roads in daily use, when breakage of rail, wheel, axle, or engine, or when collision, occurs.



Cut No. 3.—The ordinary flange and wheel, showing the proportionate height of flange which keeps the train on the track.

AT THE DOOR OF THE LEGISLATURE.

And yet, for attempting to make a safer railway with an adhesion capable of utilizing the effective pressure of any sized cylinder, I was met at the door of the Legislature by an array of money and talent to keep me from doing this thing, and decried in the press and Legislature. An "honorable" senator, shielding himself behind his title, declared me to be a scheming, blackmailing speculator, and thus they kept me battling five years before I could win even an "unduly hampered" right (and that which I did not ask for) to try my railway.

My models I put before the public. They were seen by

thousands of people, and among them a young man whom I did not know, Mr. Joseph H. O'Neil, of Boston, espoused my cause and became its champion in the Legislature, and we got in the House of Representatives the first winter, as a nucleus, an "immortal thirty-eight" of a minority, who were composed of the brains and vigor of that Legislature.

Again, the winter of 1881–82, I went to the Legislature to ask the same leave. This year the same crowd of lawyers and opponents was present at the hearings of the committee, reinforced by a stronger force of lawyers representing the railways, both steam and horse, employing altogether a better body of lobbyists and others, who purported to be able to trade votes. We carried the House of Representatives; they heard me explain my models. But in the Senate we got leave to withdraw. They would not hear me.

THE PEOPLE WANT ELEVATED ROADS.

The winter of 1882–83 found us again present. I had lectured three or four times daily on the top floor at No. 89 Court Street, with most beautiful steam operated models illustrative of the principles of the new system, to thousands upon thousands of people; this was done every day of that winter and every day of the following winter; and we sent out many, many thousand circulars, attempting to instruct the people of the city as to my invention and its effects upon property. The result was that sixty-four thousand citizens of Boston signed petitions in favor of permitting me to try my system. Almost the whole body of locomotive engineers coming into Boston daily — 350 of them — voluntarily signed a petition in my favor, after hearing me explain my system.

THE STEAM-RAILWAYS ENDORSE MY MODELS BY FORMING A SYNDICATE TO DEFEAT ME.

In spite of this the syndicate of steam-railways employed a lawyer of great renown from the western part of the State to organize and lead the horde of opponents who appeared against me. They paid, I heard, $10,000 to this man for his first winter's services. We carried the House, which again heard me, but were again defeated in the Senate, which would not.

AT LAST A CHARTER OBTAINED.

My friends as well as the enemies of my efforts began to run for the Senate, and the winter of 1883–84 found us still better organized, and in the third month of the year we got a charter. Nineteen different charters had been prepared and presented to the committees and to the Legislature, none of them giving me what I petitioned for. The one granted had been made up very largely by the enemies of my measure putting many supposed hardships into the bill, which they thought would kill it off and end my efforts, but which only served to use up time, to worry the flesh, impoverish me, tax my friends, and add very great difficulties to what I had essayed to carry out; but in nowise did they, or do they, dampen my ardor in doing that which is to benefit all mankind, as well as the friends who have stood by me.

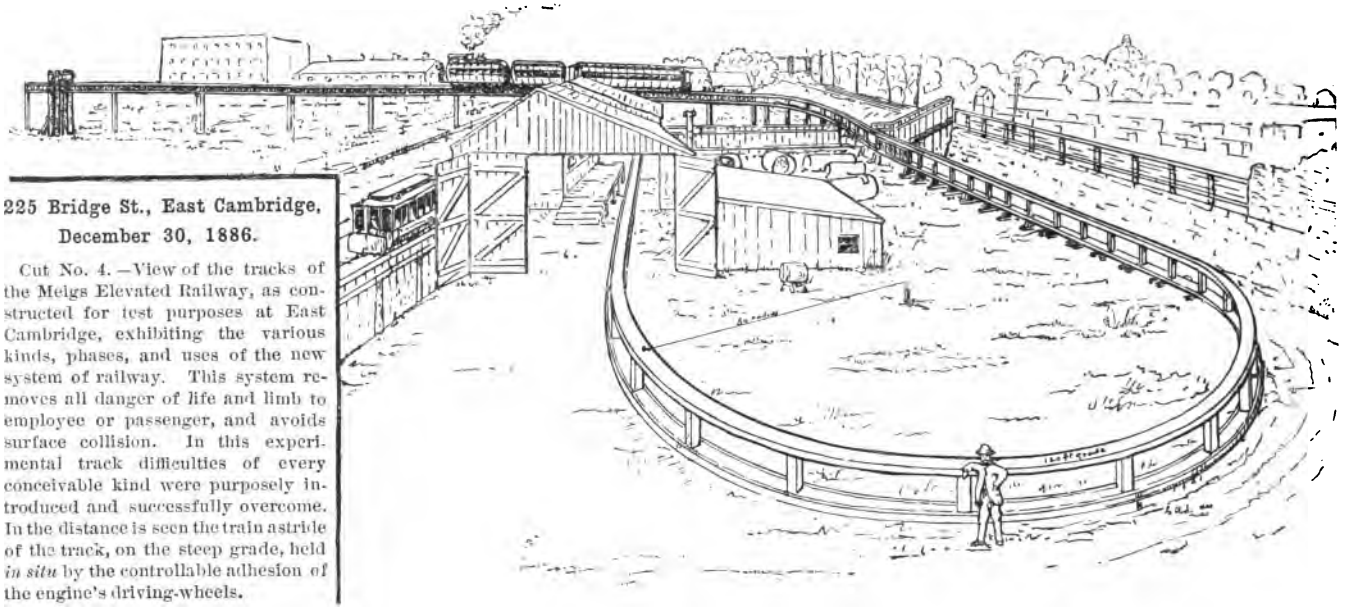
Another odd thing has occurred. In more than one instance gentlemen, who, while senators, opposed my efforts most bitterly, have, after their senatorial terms, been found as counsel, attorneys, and lobbyists trying to get charters for those "who are seeking to build railways which have never been tried" even in the model form, although they

spoke and worked against my plans, upon the ground of novelty, knowing that they had been worked out by engineers and tried by accurate models made to scale from expensive drawings. These same honorable senators loaded my bill to the muzzle to kill me off, defenceless to combat them. I trust, now the mask is off, this want of sincerity will be plain and no objection be made to give me the privileges of the railway laws as they stand, AND THAT SOME HONORABLE LEGISLATOR IN THE INTEREST OF THE PEOPLE AND OF FAIR PLAY, AFTER THE LEGISLATURE HAVING REQUIRED OF ME TO SPEND $100,000 TO PROVE MY CLAIMS TO HAVING MADE AN ABSOLUTELY SAFE RAILWAY, AND THE OFFICIAL TEST HAVING BEEN MADE BY AN ENGINEER APPOINTED BY THE COMMISSIONERS TO MAKE IT, APPROVING ALL I EVER CLAIMED, WILL SEE TO IT THAT THE GENERAL LAWS UNDER WHICH ALL RAILWAYS ARE BUILT, AND THOSE ALONE, ARE MADE APPLICABLE TO MY NEW SYSTEM.

The charter procured, I at once went to work to secure money with which to commence operations. Having been promised all I needed, I went to my friends, but found that the financial difficulties of 1884 had locked the doors to all progress: so I put my endeavors into getting ready to

CARRY OUT THE LEGISLATIVE REQUIREMENTS.

The charter of the "Meigs Elevated Railway Company" gave authority for the construction of a railway between Bowdoin Square, in Boston, and the city of Cambridge, under the patents of Joe V. Meigs and according to the plans and methods filed by him in the office of the Secretary of State, requiring that the New York system should not be



225 Bridge St., East Cambridge, December 30, 1886.

Cut No. 4.—View of the tracks of the Meigs Elevated Railway, as constructed for test purposes at East Cambridge, exhibiting the various kinds, phases, and uses of the new system of railway. This system removes all danger of life and limb to employee or passenger, and avoids surface collision. In this experimental track difficulties of every conceivable kind were purposely introduced and successfully overcome. In the distance is seen the train astride of the track, on the steep grade, held *in situ* by the controllable adhesion of the engine's driving-wheels.

used, persons having applied during these years for charters for that system and for others no less cumbersome; thus

THE ELEVATED WAY FOR THE STREETS OF BOSTON WAS CONFINED TO THE MEIGS SYSTEM,

because it offered no obstruction to light and air, and was not unsightly.

The widest part of the track was restricted to "twenty-two and one-half inches," and by the charter "no location for tracks could be petitioned for in the city of Boston until the safety and strength of the structure and the rolling-stock and motive-power shall have been examined and approved by the Board of Railroad Commissioners or by a competent engineer to be appointed by them." This was right. I did not ask more, but I did ask to build under the general laws.

To save time during this financial depression and to meet the requirements of this clause, my friends formed a construction company — of gentlemen who were fully able to meet possible losses if there were to be any, and who so understood it — to build an engine, tender, and car, and an experimental piece of way of full size.

THE TRACK WAS BUILT

so as to test every kind of way as to its quality, strength, curves, grades, post-settings, and the safety of its form and material. Every engineering difficulty which could possibly occur in any situation was put into the track and successfully overcome.

THE LOCATION PURPOSELY

selected for the experiment of setting foundations for the tracks was the worst to be found, the entire surface being

made land by filling. The refuse of the city, dumped upon the dock-mud, silt, and wash of Miller's River, covered in by order of the Board of Health. This crust was three or four years old and quite well consolidated, although the filling and understrata could be easily, and was, probed with an iron rod from six to thirty feet. If a post-supported railway could be built here without inordinate cost it could be built anywhere in Boston or even about its marshy suburbs. It was said by the railroad commissioner of Ohio that, "if a level straight track could be built upon such foundation, it was a practical test of this railway."

HOW THE PRESENT TRAFFIC IS CARRIED ON BY THE SURFACE STEAM-ROADS.

More than nine hundred trains run in and out of Boston daily, and it cannot be that fewer trains will be used in the future. It is found that cars seating from fifty-four to seventy passengers are needed, and are indispensable upon these surface roads.

POWERFUL ENGINES NEEDED.

It is a well-known fact that heavier and heavier locomotives and stronger and stronger pullers are required to draw the necessary trains of such cars. Everybody who rides upon the trains out of Boston daily must have stood in the aisles at times for miles and miles, and it is for this reason that ordinary engines from thirty-four to seventy tons in weight, ranging from 1,000 to 2,000 horse-power, with sixteen-inch, seventeen-inch, eighteen-inch, and even twenty-inch cylinders with corresponding boilers are in daily use; and it is not to be supposed for an instant that the great

railroad companies who find it necessary to use these engines which require them to build better roadways with heavier rails to support them, do it without cause.

GREAT EXPECTATIONS.

Substitutes for these engines and trains, if they are to do the same duty by the adhesion of their driving-wheels, cannot be hoped for without being as powerful or, if not so, by the use of great numbers of motors pulling great numbers of small cars; therefore, I made my engine more powerful by a grip-adhesion, while I reduced its weight.

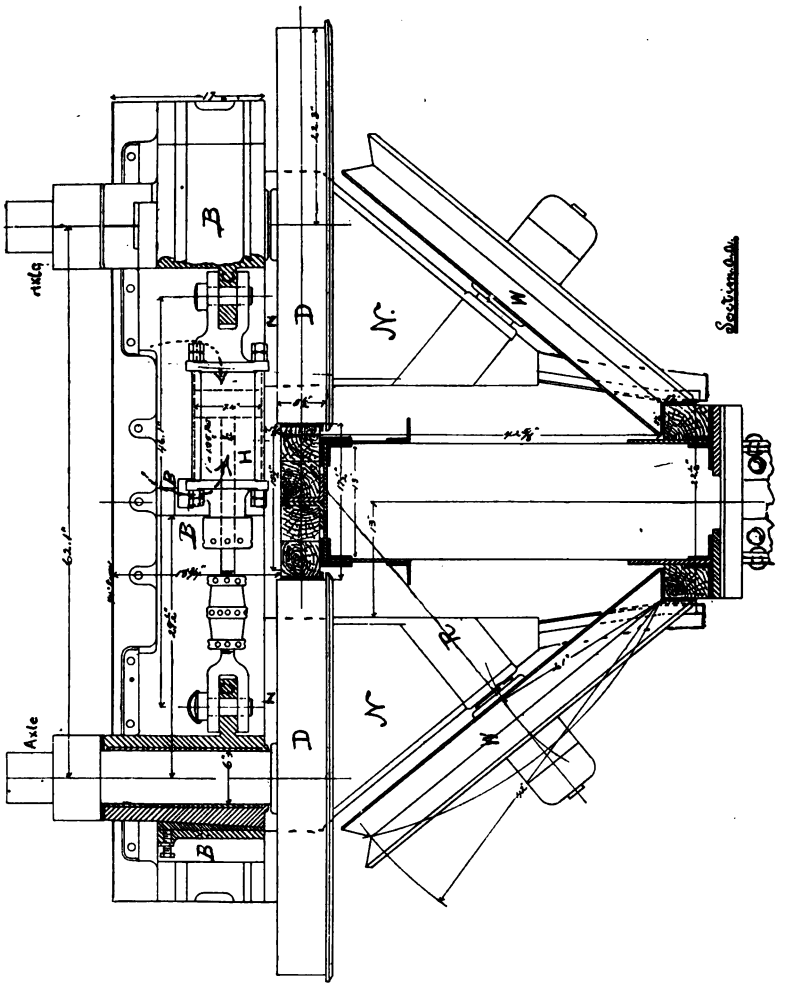
A PREDICTION.

We built a level way, abruptly meeting a grade of 120 feet to the mile, upon a half-circle or horseshoe curve of a radius of fifty feet.

It was predicted by a New York engineer who saw this completed track just before the engine was finished "that the engine, the machinery of which was to weigh in the vicinity of thirty tons, drawing a tender and car, the car being longer than the radius of the curve and seating seventy-two people, the train occupying 106 feet of the 157 feet, the circumference of the half-circle, could not traverse the curve at all, much less ascend the grade of 120 feet upon which it is built, pulling the load, because this was altogether out of the question with any locomotive yet built, and the inventor could not hope to do more than had been done."

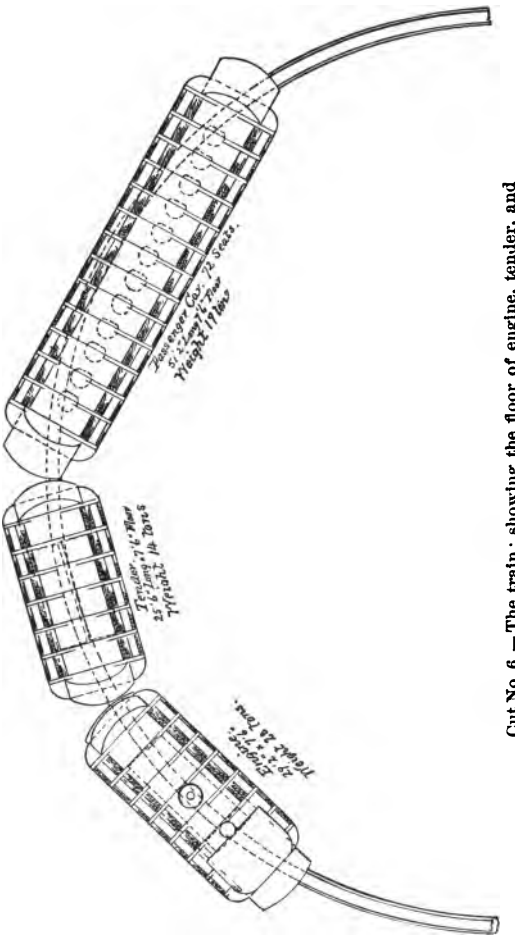
HE WAS MISTAKEN,

like many others; because the engine which he saw building has drawn him riding in the train around the 50-foot curve and up the 120-foot grade at the same time, with perfect



Cut No. 5. — D, driving-wheels. B, sliding-boxes carrying axles of drivers — upon which cranks are placed. H, hydraulic cylinder, into either end of which liquor can be let under pressure so as to pull the drivers on the track or push them off. N, N, front jaws of truck beyond drivers, carrying the supporting-wheels W, which always receive the load superimposed, whether balanced or unbalanced, by a right thrust.

ease, gaining speed upon a slippery track, which no other engine ever had done or, so long as adhesion by weight is



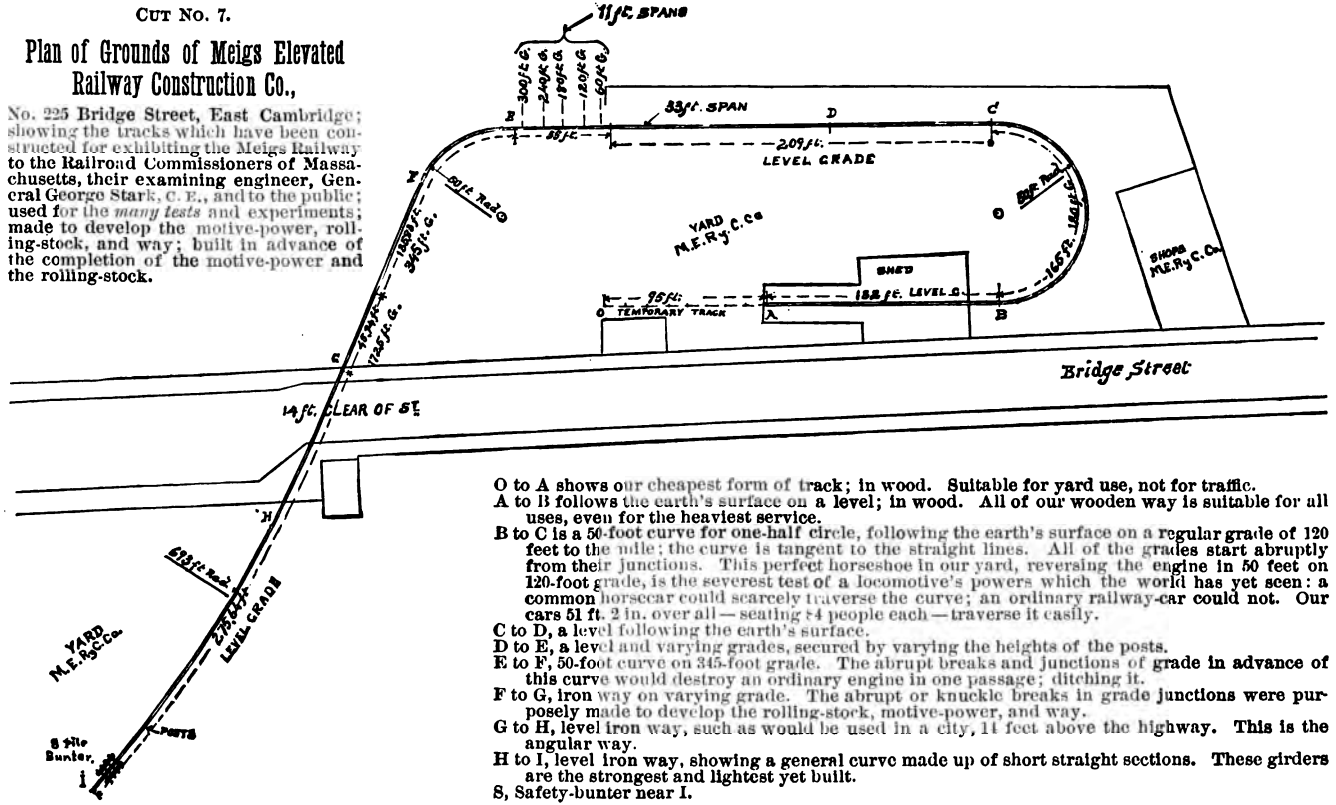
Cut No. 6. — The train: showing the floor of engine, tender, and car, with dimensions and weights.

used to get its tractive power, can ever do. And yet he found new objection that the engine did not use its weight for adhesion. He could not see! He would not see!

CUT NO. 7.

Plan of Grounds of Meigs Elevated Railway Construction Co.,

No. 225 Bridge Street, East Cambridge; showing the tracks which have been constructed for exhibiting the Meigs Railway to the Railroad Commissioners of Massachusetts, their examining engineer, General George Stark, C. E., and to the public; used for the *many tests* and experiments; made to develop the motive-power, rolling-stock, and way; built in advance of the completion of the motive-power and the rolling-stock.



O to A shows our cheapest form of track; in wood. Suitable for yard use, not for traffic.

A to B follows the earth's surface on a level; in wood. All of our wooden way is suitable for all uses, even for the heaviest service.

B to C is a 50-foot curve for one-half circle, following the earth's surface on a regular grade of 120 feet to the mile; the curve is tangent to the straight lines. All of the grades start abruptly from their junctions. This perfect horseshoe in our yard, reversing the engine in 50 feet on 120-foot grade, is the severest test of a locomotive's powers which the world has yet seen: a common horsecar could scarcely traverse the curve; an ordinary railway-car could not. Our cars 51 ft. 2 in. over all — seating 54 people each — traverse it easily.

C to D, a level following the earth's surface.

D to E, a level and varying grades, secured by varying the heights of the posts.

E to F, 50-foot curve on 345-foot grade. The abrupt breaks and junctions of grade in advance of this curve would destroy an ordinary engine in one passage; ditching it.

F to G, iron way on varying grade. The abrupt or knuckle breaks in grade junctions were purposely made to develop the rolling-stock, motive-power, and way.

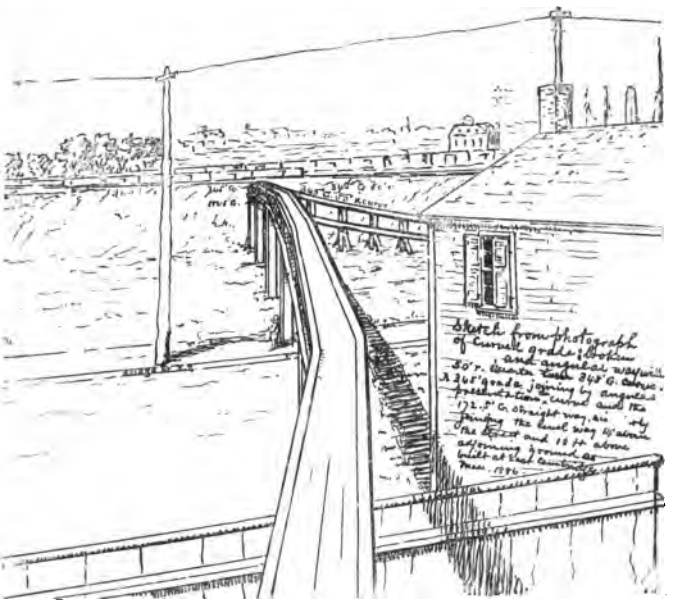
G to H, level iron way, such as would be used in a city, 14 feet above the highway. This is the angular way.

H to I, level iron way, showing a general curve made up of short straight sections. These girders are the strongest and lightest yet built.

S, Safety-bunter near I.

CHARACTER OF THE WAY AND WHY SUCH A TORTUOUS WAY WAS BUILT.

The engine, after leaving the horseshoe curve and proceeding for a short distance on a level straight way, strikes a 50-foot curve by grades of abrupt change every 11 feet, from a level to 60-foot grade, to 120-foot, to 180-foot, to 240-foot, to 300-foot, to 345-foot grade per mile. These changes are very trying on rolling-stock and motive-power, and were made to test the strength of the machinery and track. These changes



Cut No. 8. — Sketch from a photograph showing the way looking from the rear of the train, exhibiting in the distance the great grade of 345 feet, combined with the 50-ft. quarter-turn curve; the horizontal and knuckle or vertical-angular way purposely constructed for development of the engine and for demonstration purposes. An ordinary locomotive could neither traverse the grades nor curves if tracks were suited to them. One trip would destroy the engine. The centre of this way passes within eight feet of the window of the house. It does not disturb light or air.

of grade would destroy an ordinary engine were it run but once over a track of this nature. Then the engine goes up this 345-foot grade by a way making nearly a quarter-circle of 50-foot radius, thence over two iron spans, one of 46 feet, rising three feet in that length, and another 22 feet of that same grade. These spans are joined to other iron spans of *a grade of 172.5 feet;* these grades at each post meet with angular presentations, knuckled and dished. Then the way continues at a height of 14 feet 4 inches above Bridge Street.

The changes of grade, or in the direction of the track, are not made by gradual ascent, nor by horizontal curves, but by abrupt angles both sidewise and upwards, as shown by the cut.

THE ANGULAR WAY.

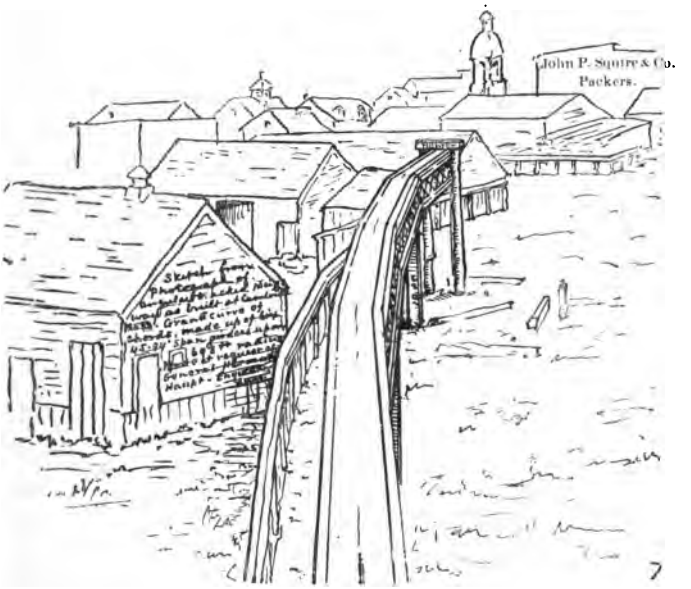
After arriving at the level, the girders form a broken CURVE OF 683-FOOT radius. The curve thus made is not a regular one, but is composed of iron post-supported girders 45.04 ft. long, used as chords of a grand arc. (This was done both to save expense and try the passage of the trucks and engine around *the angles* for my own information and to satisfy the request of General Herman Haupt, made at the time he revised the figures computed by my brother as to the strength of the way.) Thus purposely formed, they unite at the posts and make a horizontally broken track, the corners filled at the posts by short curved track pieces of wood of 50-foot radius. It is not necessary to make the track a broken curve. It may be a regular curve.

It will be seen by the following sketch after a photograph

of this part of the test track that there is thus made *an angular way*, but now broken in a horizontal direction, not vertically, as before; yet the engine and trucks traverse them without difficulty: in fact, the passage over and around these angles cannot be noticed in the car.

No competent engineer would construct a track for railroad purposes in such manner, either as to the vertical or horizontal angles.

But my track was so made to try the experiment of what strains the engine would bear and the tracks support, both vertically and horizontally, and, although the engine, tender,



Cut No. 9. — This cut is from a photograph from the front of the engine, showing the angular way built at East Cambridge for test and development purposes, over which our trains run without the passengers knowing that such track is being run over. Such a track as this, adapted to an ordinary surface railway once run over would destroy both its engine and rolling-stock, and derail the train.

and car have been driven over these angles and grades at greater speed than should be used in traversing the streets of Boston, neither has shown any weakness or perceptible strain in these experiments in the direction indicating a want of safety. In other words, we have tried all we could to break down our track and disable our engine, for if it could be done it was to be done in an experimental yard. It is but fair to say that since we made the tests we have carried many thousand passengers over these grades, angles, and curves which in a properly constructed road would never occur. Yet the motion of the train was so regular, easy, and noiseless that the passengers did not know or suspect what sort of a road they were riding over. If they had, it is doubtful whether some of them, especially those who were civil engineers and enginemen, would have ridden.

SWITCHES are but a part of the track suitably hinged, which, when thrown the least distance from the point of locking, return automatically to the main line or to switch line as the necessity of safety requires.

TURN-TABLES and DRAWS are pieces of the ordinary way pivoted and balanced so as to be swung around by power, or swung up blocking the way — both provided with automatic signals to safe points beyond.

BRIDGES are but extensions of the lines of posts supporting the same track as that used elsewhere, and present the same test strength unless long spans are desired; then they are even simpler than the old ones and greatly stronger.

DESIRABLE ADDITIONS TO THE PRESENT SYSTEM OF STEAM-RAILWAY TRANSPORTATION.

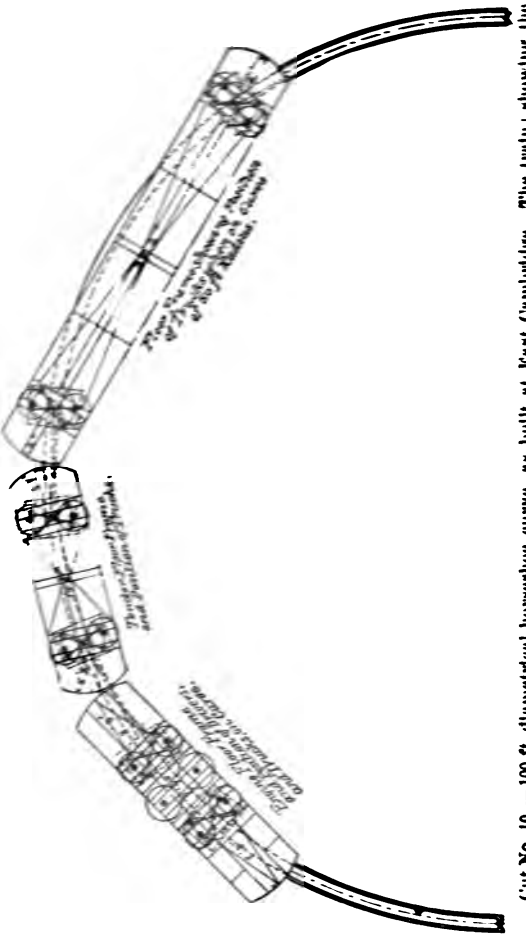
A new system should be safe. Absolute preservation of life and limb of passengers is imperative. Derailment of train should be impossible.

To have these, costs should not be counted.

My system ensures this.

IT HAS BEEN PRACTICALLY PROVEN AND OFFICIALLY ENDORSED THAT I HAVE DEVISED A SYSTEM OF RAILWAY WHICH IS ABSOLUTELY SAFE ALIKE TO PASSENGER, EMPLOYEE, AND TO THOSE NOT PASSENGERS; AND IS FREE FROM ALL DANGERS ATTENDING BREAKAGE OF PARTS AND THE SECONDARY DANGERS, ACCIDENTS, AND HORRORS RESULTING THEREFROM.

To attain cheapness of such transportation of passengers I have made a careful balance of power and resistance, so



Cut No. 10. — 100 ft. diametrical horseshoe curve, as built at East Cambridge. The trains showing the trucks as they arrange themselves in passing sharp curves; showing also the floor arrangement.

that no sensible difference is perceived as to the engine in drawing its train over a straight level track or over the same track upon a fifty-foot curve.

On a steam surface road the use of an engine and train upon such a curve would be quite impracticable.

A GENERAL REVIEW.

A COMPARISON of my system with the ordinary railway system, both on surface and elevated railways, appears to be needed to enable others to understand and judge how such great results of safety and economy have been obtained.

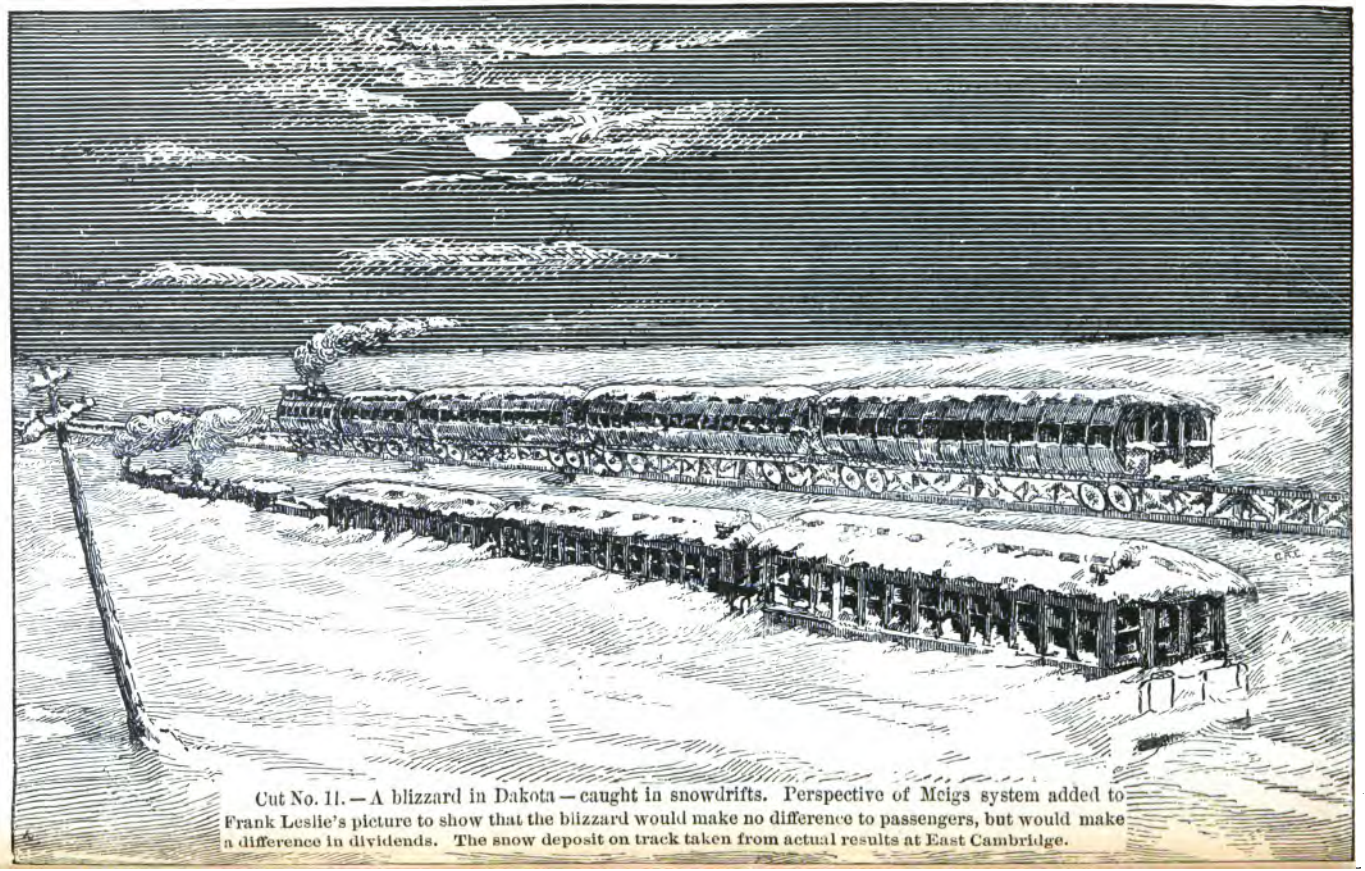
THE IMPERFECTIONS OF THE ORDINARY SURFACE AND ELEVATED RAILWAYS.

A steam-railway track which lies upon the surface of the earth is subject to all changes arising from the various conditions of that surface, whether by water, storm, snow, or frost. Its rails are put on cross-ties laid more or less closely to each other upon an earthen bed, so as to secure a general level. This bed is sought to be protected in the best railways by ditches, drains, and culverts.

MAINTENANCE OF WAY. — REPAIRS OF ROAD-BED.

In this part of the country the climatic changes in the earth's surface are very great: so much so, that to protect the bed of the railroad from changes by frost and wet only, according to the report of the Railroad Commissioners of Massachusetts, costs more than $1,100 per year per mile. This is the cost of average years; but great storms add very largely to this cost, so much that in one year of heavy storms the cost was $1,777 per mile.

There are two other sources of great cost of maintaining



Cut No. 11. — A blizzard in Dakota — caught in snowdrifts. Perspective of Meigs system added to Frank Leslie's picture to show that the blizzard would make no difference to passengers, but would make a difference in dividends. The snow deposit on track taken from actual results at East Cambridge.

the road-bed, both of which are in addition productive of great

DISCOMFORT AND LOSS OF LIFE

and limb to the passenger and employee. The first is the undermining of culverts and washing of the road-bed, bringing down from the heights above the cuts large bodies of stone and earth, which cause derailment.

For example, the washing-down by the rain of the mass of earth and rock of the track, of the State's road, near Deerfield, from which the loss of life and limb was fearful but hardly exceptional.

DETENTION OF PASSENGERS.

Second. Not so dangerous to passengers as a rule, but usually more uncomfortable, is detention of trains by drifting snow; to clear the track of which is the source of great cost to the steam-roads, not included in the above report, and to the street-railways so great a burden as to swallow up quite frequently the winter dividends, besides impeding the travel and incommoding all other methods of street transportation.

DISADVANTAGES OF SURFACE-LAID ROAD-BEDS.

In addition to this cost to the surface road, its ties lying on the earth and the road-bed becoming softened by rain, the great weight of the engines causes the ties to be crushed into the softened ground. Sometimes the ties are thrown up by the frost which follows the storm, so that the road-bed becomes very uneven, as well along its length as by one side sinking lower than the other, so as to give a jerky and uneven motion to the car, which is of great inconvenience to

the passenger and brings a great strain upon the wheels on one side, which is a prolific source of derailment and danger. Cuts Nos. 19 and 20, pp. 57 and 58, will illustrate this.

These dangers and discomforts are partially remedied in some of the higher-cost roads by ballasting the roads, that is, putting some eighteen inches of broken stone under the cross-ties, which will avoid the dangers of the water and frost if the ditches and culverts are deep enough to carry off the water and are unobstructed. This is well represented by cut No. 21, p. 58.

But while this device mitigates the trouble, I have shown that it by no means wholly removes it. Besides, the cost is so great that even very great lines of railway have merely substituted gravel, more or less mixed with earth, for plain earth as a filling beneath their cross-ties. The ballasting of road-beds by broken stone is so very costly as to be more expensive than the building of my system, which I will show hereafter is wholly free from all these difficulties.

DUST WHOLLY AVOIDED.

There is another great discomfort to the passengers upon the steam surface-roads; so annoying in the summer as to cause great numbers of them to go between Boston and New York by steamboats to avoid it, even at the risk of a touch of seasickness. All dust, as we shall see farther on, is wholly avoided, not lessened, upon my system.

SURFACE COLLISION.

There is another, much the greatest, source of loss of life and limb, and cost to the surface road, which never can be

guarded against (which cannot occur upon my railway, when built along the surface of the earth), namely, that by crossing private and public ways at grade and by the dilapidation of fences, which allows domestic animals, as well as children and drunken persons, to get on to the track unconscious of danger; from these causes many cases of derailment occur, causing large expense to the roads in breaking running-gear, and still heavier expenses in paying damages to passengers and others injured, to say nothing of the lives and limbs of the employees, which, as a rule, the roads do not pay for.

I think I have now shown some of the disadvantages of surface steam-road travel which I shall demonstrate cannot occur upon my system. But before I enter upon that demonstration I desire to call attention to the

OPERATION OF THE PRESENT SYSTEM OF ELEVATED RAILROADS.

It is a system of rails laid upon cross-ties on a track supported by girders generally of 3 ft. or 4 ft. 8½ in. gauge. This system avoids many of the dangers and difficulties arising from washouts, snow, frost, dust, and liability to collision, which I have shown are incident to steam surface roads.

Cut No. 12. N. Y. system as in the Bowery.

In so far the elevated roads possess in the same manner the advantages of my system; that is, they are

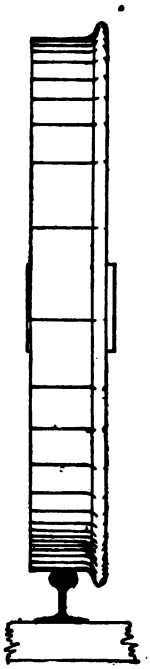
NOT TROUBLED BY SNOW, ICE,

frost, washouts, and surface collisions. Some of the disadvantages of the New York elevated roads where the wheels of the engine and cars run upon rail-tracks of 4 ft. 8 1-2 in.

gauge supported by cross-ties, are as follows: First, the cars as they pass over the cross-ties are given an uneven and uneasy motion, to the annoyance of the passengers; second, and the most important, is

THE LIABILITY TO DERAILMENT AND ITS HORRORS.

This arises from many causes: if one rail, from any weakness of the structure or the tangential pressure caused by curves or heavy storms of wind is depressed and broken; or by greatly increased force, added to an unbalanced load of passengers, one track should give way; or if one or more wheels on one side should give way; or collision should displace the flanges; or if rod or chain should fall upon the way in front of wheel, — then the whole train would be precipitated, with all its passengers, some eighteen feet into the street below, producing results so appalling and frightful, and of such cost to the railway, that it is impossible to foresee its consequences. This would be exactly such an accident as the awful deck-bridge disaster at West Hartford, Vermont, with its 38 dead and 33 injured.



Cut No. 13. — Showing flange on wheel 1 in. high, the only safeguard against derailment and death.

The only guard in the present system of elevated railroads against derailment and the horrible consequences I have suggested is that the train has for its only safeguard an inch flange on each wheel, and if that flange breaks on one of them, derailment of train is almost certain. The effects of derailment in New

York have been, as in the West Hartford holocaust, to cut through those wooden stringers on each side of the rail which distribute the longitudinal strains, and they serve very little to secure safety. This can never happen upon my system because every wheel of every car may be thrown off its bearing surface and still the trucks will be 48 inches astride of the track; there can be no derailment or ditching of the train; and no such sorrows could be brought upon peaceful households as in the recent calamity. The only result of such an accident would be that the trucks of the cars come down an inch and a half upon the rail and glide ALONG until checked by friction or the other appliances for that purpose. We have

TESTED THESE THINGS BEFOREHAND.

My train runs daily over a rail broken at several points and rails are left purposely unfastened over which we run; thus I have demonstrated that derailment accompanied by ditching can never happen upon the system of elevated road that I have constructed, and frightful accidents from derailment are impossible upon my system.

LUCK, NOT FOREGUARDED.

It may be said that the New York Elevated Railroad has carried a great many millions of passengers for several years with injury to but few passengers sitting in their places. That is true: but it has been run as a new road with all its machinery perfect and unworn and at comparatively slow speeds. That is not an argument. Of that we have a pregnant example in this Commonwealth. For more than the first quarter of a century the Boston and Lowell Road

ran its trains without substantial injury to a single passenger who sat in his place; but the records of its later years unfortunately show that many passengers have been injured, for whose lives and limbs the road has paid. Derailments have occurred during that long period on that road and they have also occurred on the elevated road in New York, but they were fortune favored. Upon my railway these dangers I have sketched will always be avoided.

COLLISION OF TRAINS.

Some critical railroad engineer may say there is one danger of collision on railroads to which you have not alluded, perhaps because your system provides for it no remedy; and that is the collision of two trains on the same track running in the same or different ways.

To that I answer that on the ordinary surface road there is that danger, as also on the New York system of elevated railroads. On those roads I know of no way of preventing it. It ought not to happen. Nothing but the worst possible management would allow it so to do. Upon my system I have made seven improvements looking to security from collision.

1. BREAKING TRAINS INTO SECTIONS.

The great weight of trains when securely coupled together, when no one of the cars can be detached, is a fruitful source of danger from that kind of collision when one train is following another. By positive mechanical means I have provided that the engineer shall be able to uncouple and detach each one or all the cars of his train at will, putting on the

brakes of the detached cars, thus breaking the force of collision into a series of slighter concussions.

2. BUFFER INSTEAD OF COWCATCHER.

Besides, I shall have attached to my engines a buffer extended by an air-spring, which wholly takes up, or, in any event, greatly relieves, the force of concussion, and I believe it to be, and can demonstrate it by experiment, a measure of great, if not perfect, safety in case of such collisions.

3. REDUCED DEAD-WEIGHT OF TRAIN,

therefore of momentum, is secured by the system of controllable, instead of weight, adhesion of engines and by my system of building lighter cars.

4. TRAINS ARE TIED TO THE TRACK

by the horizontal wheels which hold the floors of the train in one unbroken line of resistance to shock.

5. COUPLERS LOCK THE END OF CARS DOWN

at moment of collision. Engineman can reverse his engine and

6. INCREASE THE ADHESION OF HIS DRIVERS

up to the maximum power of the cylinders.

7. I have made the floors, the platforms, and the bracings heavier, with their materials so placed to resist collision as to give the greatest strength; besides, there is no difficulty in applying a telegraphic system to my track which will keep in order.

These are at least greater advantages than now exist in the present railway.

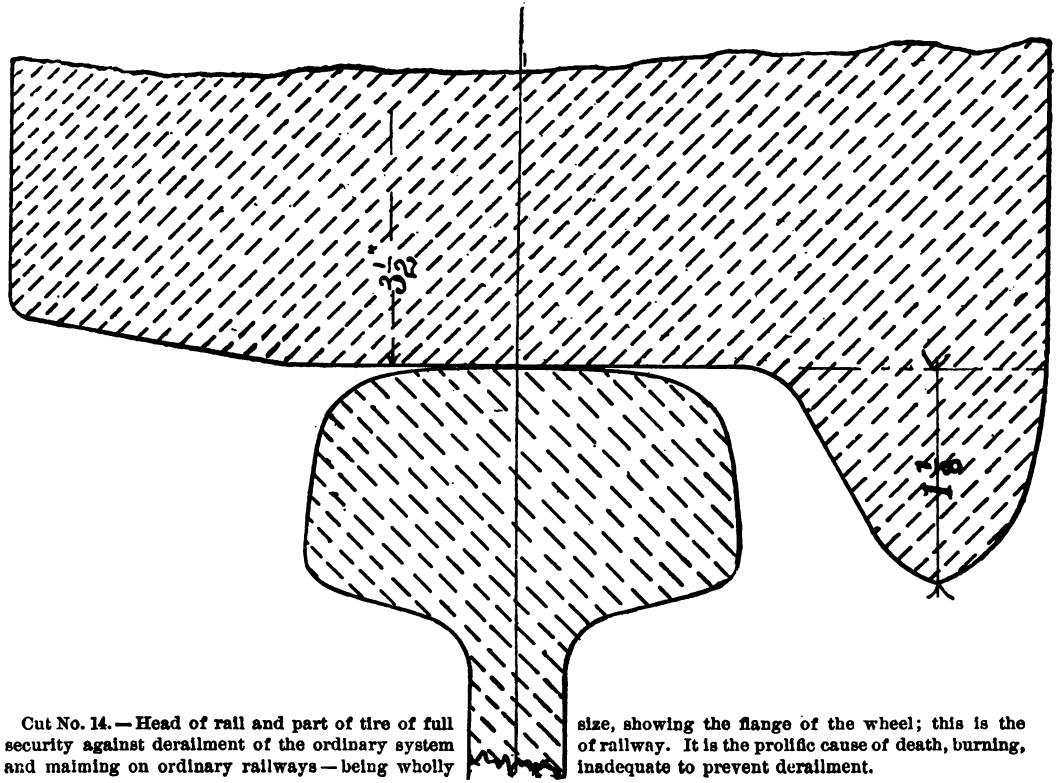
It will be observed that thus far I have only dealt with the difference in safety between my system and present systems, whether elevated or surface roads, because I deemed those points of last importance to the road and its passengers. I will, after treating of the differences between my system and the present ones in the above-mentioned regards, speak of the comparative differences of cost and the economy of running my system of railway.

Having stated the difficulties, dangers, and annoyances of surface-railroad travel and also the great danger of the present system of elevated railroads, because of possibility of derailment on them accompanied by a grand plunge, I give

A GENERAL DESCRIPTION OF MY SYSTEM,

which is adapted to travel across the country, or by elevating the track and putting it on iron columns it becomes my elevated system.

My columns, or posts, sufficiently strong by test to stand any possible vertical or lateral pressure, are placed in the ground and properly secured, preferably in a foundation of concrete and broken stone. See cut No. 2, p. 9. Using our post-setting system it is necessary but very seldom to resort to piling. My system of post-supported railway entirely abolishes the road-bed and its surface changes from standing moisture; the upheaval by freezing, breaking the alignment and making a rough road; the softening by rains, the ditch, the choked waterway, the culvert, very much of the cutting, the embankment, all of the smaller bridges, much simplifying the larger ones and making the crossing of streams and lands likely to be flooded very much less expensive and free



Cut No. 14. — Head of rail and part of tire of full size, showing the flange of the wheel; this is the security against derailment of the ordinary system of railway. It is the prolific cause of death, burning, and maiming on ordinary railways — being wholly inadequate to prevent derailment.

from detentions and dangers. My system eliminates danger from washouts or undermining; reduces the costs of repair, removes the causes of detention, of damage to life, limb, and property; makes less cost of right of way because my post system is not unsightly, and it relieves the field, lawn, and street from the hindrances, annoyances, and difficulties of the present system of elevated 4 ft. 8½ in. gauged railways.

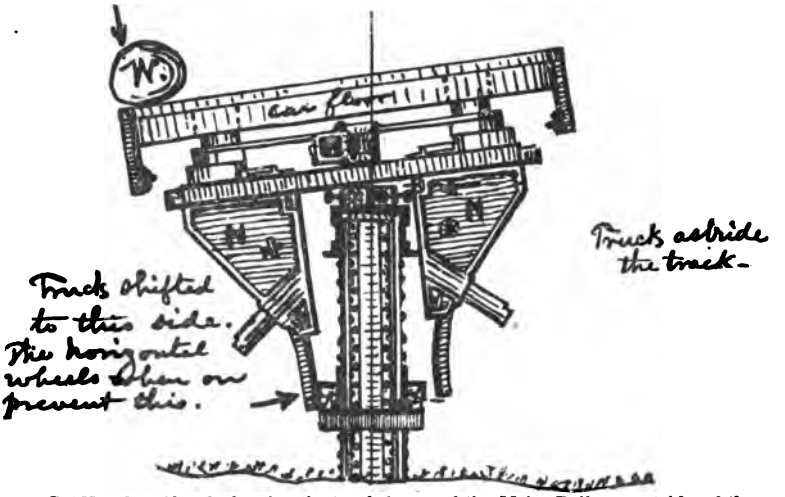
Supported by these columns is a thoroughly braced girder reaching from column to column, resting upon a concrete filling in the column (see cuts Nos. 62 and 63, pp. 140 and 142), which is thoroughly rammed to support the load and thus reserves the strength of the iron of the column for resistance to bending and thrust. The girder is provided with grooves in the outer faces of its upper boom as well as in its lower boom, in which continuously running wooden cushions, or tie-pieces, rest, to which the practically continuous rail is fastened and upon which the inward counterbalancing pressures of the laden wheels are received, thus forming a four-railed track.

On the rails of a common 4 ft. 8½ in. gauge elevated road is placed a pair of wheels with *one-inch flange*, to keep the cars on the track and to hold them on the track at curves and in case of collision. I deem such a system merely an invitation to terrible accidents which will empty the pockets of the company using it one of these days.

This prophecy is fulfilled by the West Hartford accident, which will be repeated from time to time as long as the present system is used.

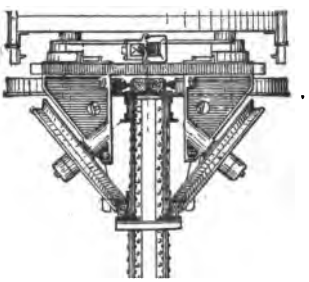
I have placed upon my girder-way a truck-frame made of the strongest iron riveted and bolted together, *straddling that*

way four feet down, forty-eight inches instead of one inch. Upon this I have placed such wheels as will make the least friction and give the greatest security, and over which one



Cut No. 15. — Sketch showing the truck-frame of the Meigs Railway astride of the track at a post. The wheels have been left off to show the utter impossibility of derailment, and it is clearly evident upon inspection of this sketch that mere breakage of rail or wheel does not endanger the lives of the passengers. It will be noted how securely the car floor is attached to the truck.

may ride in peace of mind with speed and comfort and without fear of death from being hurled into the streets below, or from the tops of bridges, and which will not imperil, by payment of damage, the money invested; instead, there is absolute safety and security, with less wear and tear, and a capability of using longer cars with heavier traffic, reducing the weight of train per



Cut No. 16. — Meigs truck astride of way 4 ft.

passenger, increasing the interval between trains, and making a higher speed safe at less cost. These girders will sustain any vertical or lateral pressure which heavy service may require. In the ordinary unevenness of the ground or streets, by lengthening or shortening the columns the track is made level. See cut No. 28, p. 69.

The reader will please observe that, in the face of my costly demonstration and of its official approval, — the West Hartford horror filling the columns of the newspapers with the sickening details, — they do not have the decency to say that there is a system which, if used, would be free from such sad results.

My engine can ascend, without difficulty, a grade more than quadruple any other grade that has ever been overcome by any surface or elevated railroad. Thus it will be seen I have overcome all the difficulties and dangers that are inherent in surface or elevated railroad traveling. A comparison is made in the following table, which is quite complete. It shows that the ordinary surface road will not bear criticism or examination, and that mine will.

PARALLELISMS.

The ordinary 4 ft. 8½ in. gauged railway, surface-laid and as elevated upon posts, compared with the Meigs system of elevated roads.

I have placed the facts of the ordinary railway practice in columnar form and have placed in apposition the results of my demonstrations; they are conclusive, being based on facts. I made such a parallelism when the serious business of making my first drawings, now many years ago, was commenced.

Then the column now occupied by my railway was one of interrogation, how shall I get rid of, or diminish the fault, or increase, or make better the merit.

3 FT. AND 4 FT. 8½ IN. GAUGED SYSTEMS.	MEIGS SYSTEM.
Surface-laid roads are exposed to the surface requirements of cost, repair, and damage.	Post-supported railways are free from surface requirements; the Meigs system eliminates most of the costs and all of the dangers.
Carefully finished road-beds required.	Road-beds will be far less expensive.
Expensive grading required. Very costly!	Quantity of grading very greatly reduced. Reducing costs!
Overflowed tracks. Danger!	Tracks above overflow. No danger!
Ditches continually to be looked after. Danger!	Ditching rarely required. No danger!
Waterways to be kept constantly clear. Danger!	Waterways almost universally open, and not dangerous at any time!
Embankments frequently washed away, requiring expensive renewals. Highly dangerous!	Washouts not possible. No danger!
Tracks on surface of ground liable to be undermined in time of storms by running water. Very dangerous!	Tracks elevated, and safe from running water. No danger!
Road-bed beneath the ballast saturated from overflowing or obstruction of ditches. Danger! Expense increased.	Road-bed of iron, not in contact with saturated ground. Hence not disturbed. No danger. Expense eliminated!
Settlement of cross-ties in wet weather, necessitating track repairs. Danger! Expense!	No settlement of timbers carrying the rails on this elevated way. Danger and costs eliminated!

Cross-ties subject to rapid decay from alternations of heat and dampness. Danger and costs!	Timbers carrying rails less subject to dampness, and therefore more durable. Danger eliminated, costs reduced.
Cross-ties require tamping and retamping. Danger and costs!	Timbers carrying rails, when once laid in place, remain permanently in place. Danger and costs eliminated!
Rails unevenly supported on cross-ties. On ordinary elevated roads the same. Costs and dangers!	Rails continuously and evenly supported. Danger and costs eliminated!
Tracks displaced as to surface and line by frosts and freezes. Danger and costs!	Elevated tracks not affected by frosts and freezes. Dangers and costs eliminated!
Numerous culverts required. Introducing danger!	Culverts rarely required. Reducing costs and removing the dangers!
Limited bearing surface of wheel on rail, occasioning hard-faced wheels out of true, and making hard-riding cars.	Broad-faced true wheels. Difficulties of strain and wear obviated. Increasing comfort, reducing costs.
ONLY A FLANGE ONE INCH HIGH TO PREVENT DERAILMENT TO 4 FT. 8½ IN. GAUGED ROADS ON ELEVATED AS WELL AS ON SURFACE-LAID ROADS.	EACH OF THE TRUCKS ASTRIDE OF THE WAY 48 INCHES; DERAILMENT ABSOLUTELY PREVENTED AT ANY SPEED.
Speed increases danger. One never rides over them without imperiling life and limb.	Speedy trains absolutely safe. No peril. No fears.
The elevation of the ordinary gauge reduces liability to accidents, but increases their severity.	The elevation of the Meigs Way removes entirely all of the causes of accident, prevents derailment entirely, and renders travel safe.

Telescoping of cars due to weak platforms and imperfect coupling.	Platforms and couplings prevent telescoping.
Derailment possible from many causes.	Derailment not possible.
Smashing of truck causes derailment of train.	Smashing of truck can rarely happen, causing no ditching.
Breakage of rails almost always attended with disaster.	Breakage of rails scarcely possible, and causing no disaster.
Broken axle attended with disaster and costs.	Broken axle not likely; when occurring, no disaster.
Breakage of wheel causes derailment.	Breakage of wheels cannot cause derailment.
Rails pressed asunder by rolling wheels. Danger!	Rails pressed inwards and with counter-pressures. Safety.
Vertical wheels receive load vertically only when balanced loads are borne. Unbalanced by winds or load they are twisted.	My inclined wheels receive their load always at right angles to axles, and are never twisted.
Wheels have flange frictions, adding to costs of hauling loads Size of wheels limited.	Inclined wheels have no flange frictions. Large wheels used. Size practically unlimited; riding easier.
Wheels are fixed on their axles in pairs and are continually dragging one the other. Very dangerous.	Inclined wheels run each on its own axle; they cost less for repairs and pull easier. Free from danger.
Imperfect oiling, attended with waste. Hot-boxes. Danger.	Perfect oiling, without waste. No hot-boxes. No danger.
Lateral motion. Side-shocks of train when in motion.	No lateral motion. Side-shocks scarcely perceived.

No provision to diminish the violence of collisions, save by increasing weight of cars, which adds to momentums, to wear and tear of road-bed, and making secondary results from breakage more severe.	Effects of collisions diminished by cushioned buffers, taking place of cowcatchers. By breaking train up. By reduced weight of train. By trucks tied to track. By regulable adhesion of engine with reversion. By keeping line of strain in line of strengthened floors of cars, or in all 7 new safeguards are added.
The cars, to get strength, are very heavy.	My cars save from four to seven tons each with greater strength.
The vertical walls of cars have to sustain heavy wind-pressures.	Wind-pressures reduced one half by cylindrical cars.
Seatings limited.	Seating increased nearly 50 per cent. by my arrangement in cylindrical car.
Windows admit dust, dirt, cinders, cold, and drafts. Uncomfortable!	Windows do not admit dust, dirt, cinders, cold, and drafts. Comfortable!
Trains may be burned with disastrous results. Walls of cars require repainting, recovering, etc.	Cars lined with iron, so that fires will not spread. Walls of cars do not require these repairs so often.
Wear and tear very great.	Wear and tear, absence of causes, greatly reduced.
Repairs of road-bed, as shown by report of Massachusetts Board of Railroad Commissioners for 1886, $1,140.05 per mile per annum; add repairs of bridges, $177.76 per mile per annum. Total annual repairs of road-bed and bridges, $1,317.81.	Repairs of the Meigs Way can scarcely exceed $607 per mile per annum, being confined almost entirely to renewals of track-stringers, occasional adjustments of rails, and repainting the iron-work.

No contingency included.	Our estimate fully covers every contingency.
Adhesion of driving-wheels, due to that part of its weight which rests on the driving-wheels, cannot be increased or diminished.	Adhesion of driving-wheels, brought about by hydraulic, air, steam, wedge, screw, cam, spring, or lever pressures, or by a combination of these, independent of weight of engine, is increased or decreased at the will of the engineman.
View of engineman limited.	View of engineman unlimited.
Power of enginemen over train limited.	Power of enginemen over train increased and quite unlimited.
Grade limited by resistance of gravity and because whole tractive power of engine cannot be used.	Grade only limited by cost of operating. Whole tractive power used.
Wind of 110 miles per hour causing a pressure of 33 lbs. per square foot against the walls of the train would overturn it, engine and all, on a surface road and would hurl the cars of such an elevated road into the streets below. This is horrible to contemplate.	Wind of 110 miles per hour would not dangerously affect the Meigs structure, nor imperil a train of 51-foot 2-inch passenger-cars carrying a double "unbalanced" load of passengers. We have put that strain on, and have tested the question.
The cars are mere crushable wooden boxes. Burnable, from the stoves used — the only method of heating found practicable when it is necessary to heat cars on sidings and in waiting. A very terrible thought.	The cars are iron-framed, floors, walls, and roof; all the wood used is closely lined with metal, and thus unburnable from itself. Stoves therefore may be used without fear of the spreading of the fire, were it possible to smash a car. A very solacing thought.

Loads borne at remote point from centre line of way require increased weights of elevated railway girders, and reduce their strength.	Concentrating the strains near centre lines of posts removes leverage against us, reduces weight, and increases strength of way.
With weight-adhesion as used on elevated roads of 4 ft. 8½ in. gauge, the weight of engine and size of cylinder, hence the size of the train, is limited by the strength of the roadway.	The system of adhesion reduces the weight of engine but places no limit upon size of cylinder, speed, or size of train.
On surface roads cars with 156 seatings occupy 159 feet of track. On New York elevated road cars seating 192 passengers occupy 181 ft. 4 in.	Cars seating 252 passengers occupy 153 ft. 6 in. of road.
Or length of train per passenger for surface system, 1.02 ft. N. Y. elevated railway system .81 ft.	Length of train per passenger for Meigs Railway System .60 ft.
Dead-weight per passenger hauled, elevated roads, New York, 497 lbs.	Dead-weight of car hauled per passenger, 404 lbs.
Dead-weight of car hauled per passenger, standard cars of surface road, 807 lbs.	
Steam-boiler confined to certain limits.	Boiler can be built as desired.
In elevated roads of 4 ft. 8½ in. gauge, adhesion of engine secured by its weight; this weight is limited by strength of girders. Boiler limited, steam limited, cylinder limited, pull limited, speed limited, number of trains increased, intervals shortened, weight per passenger increased, momentum increased, dangers increased, horrors multiplied, profits imperiled.	With controllable power-adhesion, the heavy weights of girder not required, cost girders reduced, boiler not limited, steam unlimited, cylinder unlimited, pull increased, speed increased, number of trains diminished, interval increased, weight of train per passenger and momentum decreased, dangers eliminated, safety, pleasure, comforts, and profits secured.

The items of repair which enter into the science of railway management in Massachusetts for 1886 per train per mile are as follows. And in view of the results attained at East Cambridge, I can justly say in comparison, for

	4 FOOT 8½ INCH GAUGE. PER TRAIN MILE.	MEIGS SYSTEM. PER TRAIN MILE.
Repairs of road-bed,	$0.118	Estimated $0.063
,, of bridges,	0.023	
,, of rails,	0.015	0.005
,, of locomotives,	0.054	0.027
,, of passenger-cars,	0.035	0.005
,, of freight-cars,	0.035	0.005
Wages,	0.263	0.225
Oil and waste,	0.008	0.003
Fuel,	0.094	0.080
Totals.	$0.650	$0.413
Repairs per year per mile of road-bed with bridges, as reported to R. R. Commissioners		$1,317.81
Repairs per mile of road-bed and bridges per year, as estimated from experience at East Cambridge		607.00

In comparison with other systems of elevated railways, and particularly those of 4 ft. 8½ in. gauge, the advantages of this system are: that it removes all possibility of derailment, whether by collision, wind-pressure, unbalanced loads in crowded cars, by breaking of wheels or axles, or the rising-up of the wheel-flange of only an inch on to the rail, which is one of the greatest sources of danger to life and property. In addition, my tracks cause no obstruction of light or air in the streets, and are hardly more noticeable than the lines of the lamp-posts. This you should see for yourself at East Cambridge. The way will carry the system of telegraph wires on or in the girders, saving the enormous expense of putting them underground, and which are found to be, when elevated on poles, so dangerous and obstructive to firemen when called to put out fires.

On ordinary railways the PRIMARY accidents, such as breakage of wheels, rails, rods, cross-ties, etc., are seldom the cause of loss of life in themselves. Those which occur to the engine sometimes are such as breakage of wrist-pins, cranks, connecting-rods, steampipes, etc. It is, rather, first the breakage of some part which causes derailment, the catastrophe being SECONDARY to the PRIMARY accident. I will illustrate: —

First. Collision. This is a primary accident, causing telescoping of cars, which is a SECONDARY result, occasioned by inability of the cars to remain upon the rails, or, in other words, to keep the strains in the line of the floors of the cars; the result is that one car mounts over the other and rushes into it, jamming people in the wreck and causing great loss of life and property. Burning, in such a case, is also a secondary result.

Second. Accidents to engine. These not only kill the engineman and assistant PRIMARILY, but cause, SECONDARILY, derailment and its attendant terrible consequences.

Third. Breakage of rail, wheel, truck, or rods. These primarily are very simple and, in a properly devised railway, should be harmless; but the SECONDARY results are very serious, often attended with great loss of life and limb, and always resulting in great damage to the railway property.

What I have succeeded in doing in my system is to REMOVE ALL SECONDARY EFFECTS and confine the accident to the primary ones, which are absolutely harmless and attended with no danger to life or limb; at the same time in very great measure removing all cause for EVEN PRIMARY ACCIDENTS. I will illustrate the results of the same causes of accident when my system is used.

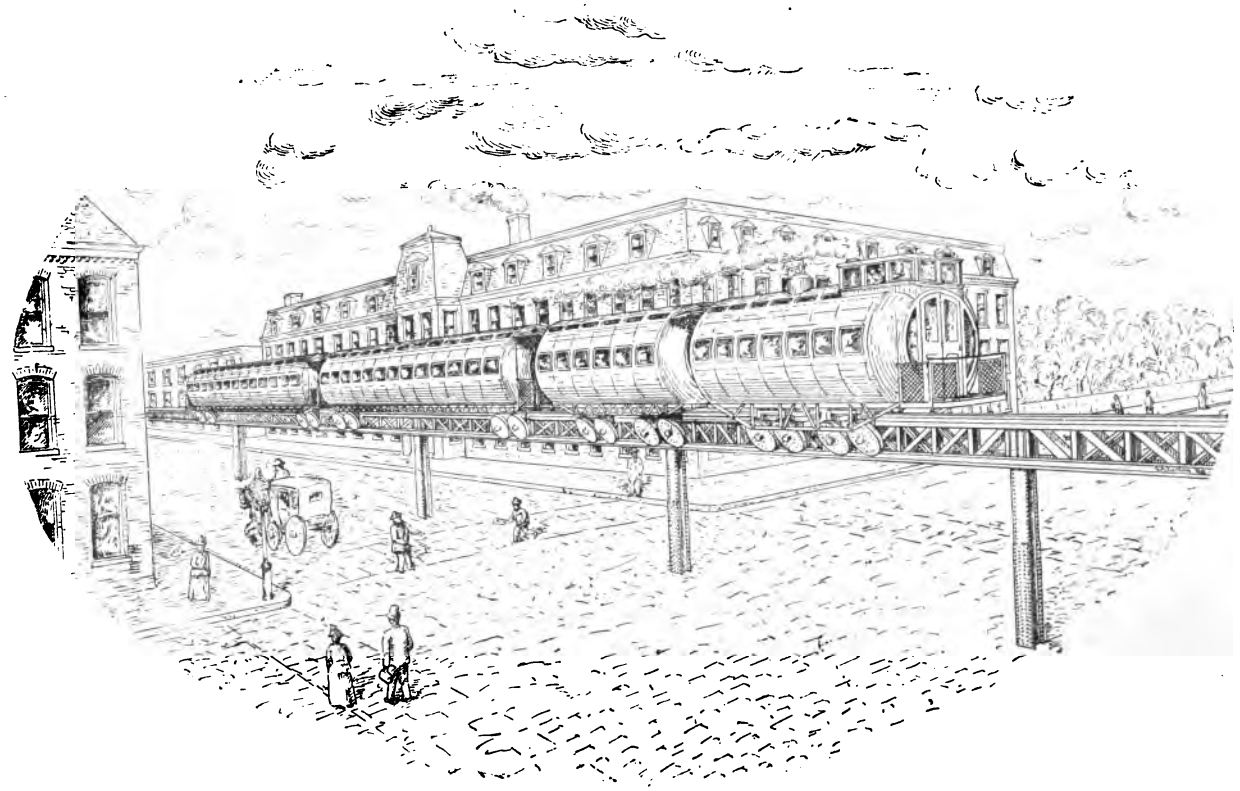
First. Collision. This may occur upon my system of railway, but telescoping of cars would be impossible, because my cars are built with extraordinarily strong floors, extraordinarily attached to the trucks astride of the way for 4 feet in depth, which are locked to the track by the balancing-wheels running under the upper boom, so that in collision the cars cannot rise up or move sideways and the strains are of necessity kept in the direct line of the floors; but in addition, by my system of coupling, if a collision were imminent, the train could be broken up into sections, each car separated from the other, powerful automatic brakes being applied, thus dividing the force of the momentum into a series of comparatively slight blows.

Second. Accidents to the engine. On my system these could not by any possibility result in derailment, which is a secondary result. The part or parts would break without affecting the engineman, his fireman, or the cars in the train, and that would be the end of it.

Third. Breakage of rail, wheel, truck, and rod. In my system it has been practically demonstrated that the breakage and loss of these parts cannot occasion derailment or accident of any kind that by any possibility can endanger life, limb, or property, and the loss to property could be computed, when discovered, by the cost of the part broken.

A glance at the cuts showing the construction of my railway will, to the observing eye, demonstrate all these advantages.

I ought to call attention to one, and perhaps the greatest, improvement over either surface or elevated roads, which is not so obvious to the eye, and, by unreflecting people,



CUT No. 17.

View of Meigs Railway as constructed in the middle of the street—offering no interference to light and air, and presenting a safe railway

even engineers, is not fully appreciated. The capability of using the traction, or drawing-power, of the present systems comes from the adhesion of the wheels pressed by the weight of the engine upon the top of the track. See cut No. 24, p. 63 This requires engines of such enormous weight to get sufficient adhesion to draw trains that the weight of the locomotive since the first one ran in this country on the Lowell Road, has increased from six tons, with which that road was operated, to more than seventy tons with which the grades on the Pacific Road are overcome. This weight is a frightful source of accidents and of displacement and wear of the rails.

I have obtained adhesiveness for traction purposes by having my driving-wheels, two or more, run horizontally against the sides of the upper rail, and then by means of the well-known hydraulic pump, or by equivalent means, I press those wheels opposite to each other against the rail, getting any required traction power without any weight upon the upper rail; there is absolutely no weight upon my upper rail either while the engine rests on the track or is in motion; thus the centre of momentum and of gravity is vastly lower and safer than was ever known before, while the loads are concentrated, with shorter leverage against us. It can be seen that the weight of the ordinary engine only presses upon one point on the rail and gets only the power of that pressure which is lessened by grade. My wheels clasp the rails on each side and get precisely a double amount of traction to that got by ordinary wheels from a pressure by weight of an equal force, or, in other words, by half-pressure on the rails I get double traction power, which

is not lessened by grade, so that all slipping, while doing its fair duty, of the locomotive-wheels on the rails is avoided, which slipping loses more than twenty-five per cent. of the speed in fast trains on surface roads. My system thus enables the engineman to pick up speed by increasing his adhesion at will, so that at East Cambridge my engine in climbing a grade of 120 ft. upon a 50-foot curve for 165 ft. followed by a level of 209 ft. has gained a speed of 33 miles an hour. Besides, my driving-wheels running horizontally can never be derailed and an axle will never be broken, because the wheel running on absolutely plain and even surfaces, no jumping or jouncing of the engine can take place; but, if an axle were broken, it would not cause injury of any kind.

In addition, there is no friction on my wheels running round a curve, however sharp, and the ominous and suggestive unpleasant grinding motion and sound of the wheels as they ride the rail on the surface roads, or other roads of the same gauge, upon a curve wherein one wheel on the axle is turning and the other is dragged, is wholly done away with. This dragging upon the curve is a fruitful source of displacement of the rails and derailments of trains on the surface roads, and with any speed upon the elevated roads of the same gauge the dangers to be faced are, to those who understand them, hair-blanching. Having thus made comparisons between the two systems, I beg leave to give a more extended explanation of the appliances and mechanical devices and mechanical means by which my system has been perfected and, in part, the studies which led to it.

I trust, if it is tedious, I may be pardoned, because it is

done for the information of those who desire to know how such great results are obtained, and who wish to be convinced of the facts and to know mechanically they do exist, and scientifically ought to exist, in my system.

A car to carry passengers is the first detail to be considered. To determine the size and apportion the rest of the railway to it we must examine

THE CARS FOR STREET-RAILWAYS AND THE PRINCIPLES GOVERNING THEIR USE.

In carrying out *the principle* upon which transportation has been laid for street-railways, it has been found that a car seating about twenty-two passengers is as large as can be well admitted into the streets of most cities and ought to be run singly, not in trains, for very many reasons, such as time, hindrance, danger, etc. The speed at which they may be run is limited to from four to six miles an hour, the speed being governed by the rapid increase of danger with increase of speed; therefore it is that *electric and cable railways* used upon the surface of the streets, being controlled as to the size of their cars exactly by the same rules that govern the size and number of horsecars which can be used in the streets, are but mere substitutes one for the other, in no way increasing the capacity to move greater numbers readily and, in fact, adding a little more to the cost; it being therefore *a luxury* simply to be able to run the cars without horses. Roads elevated above the street surface admit of larger and longer cars being used, and in trains, increasing the interval between them in proportion to the greater number of seatings secured, thus decreasing the danger. The drawing-power of the engine is increased,

because its adhesive wheels are removed above the grease and other lubricants of the streets. It has been proved the world over by extended tests that surface-laid roads in cities furnish bad tracks for small motors dependent upon weight-adhesion for their capability of utilizing the tractive power of their motors, as slipping increases with speed, rendering them uneconomical; whether electricity, steam, air, or what not, furnish the power.

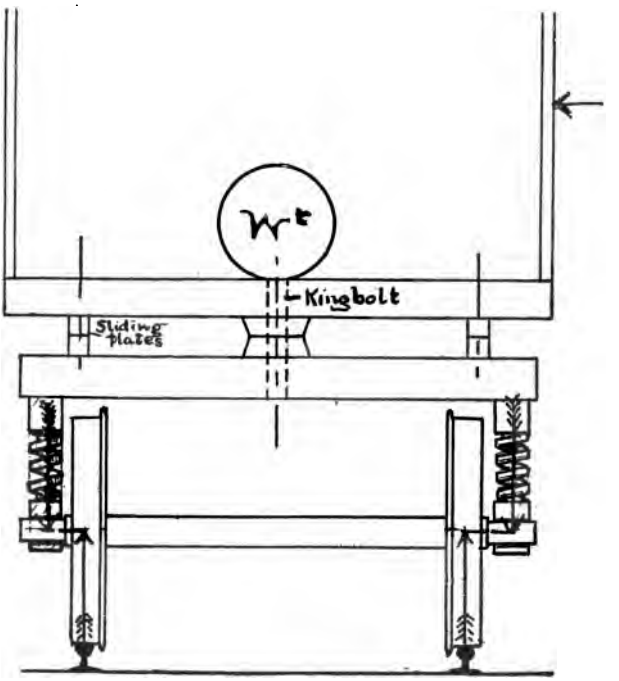
A REVIEW OF SOME OF THE PRINCIPLES OF RAILWAYS.

But as my purpose is to present not merely a substitute for the present system but a system by which larger numbers can be carried more safely, with *incomparably* greater safety, we must review the present system to be able to judge of the merits of the changes I propose.

The *culvert* is a constant source of annoyance, and often causes the damming of a stream and, as a result, a washout. The *ditch* holds water on the side of the railway, often so as to keep it beneath the cross-ties (see cut No. 19, p. 57), rendering them unstable. The *rails* laid upon the cross-ties are but simple girders spanning from cross-tie to cross-tie so as to support the load to be carried, and ought to present a rigid surface upon which the wheels of the engine are to apply the power of locomotion. The rails of an ordinary railway must be stiff enough not to bend or yield under the pressure of the engine, otherwise the engine would always be climbing a grade of great altitude.

Because of *the limited surface of contact of wheel and rail*, theoretically a mere line, practically found to vary from about .13 of a square inch to .72 of a square inch, as the rails and

wheels are new or old or whether the track is yielding, there is necessity of a hard-surfaced rail, to stand the loads which are hammered over them — *the hammering* caused by the rolling over them of the loaded wheels rolling now over a well-supported cross-tie and now over one unsupported, and now over the elastic space between the ties, and now over a solidly supported tie, and so on and on. This in turn necessitates *a hard-faced wheel.* These things are all disadvantages and can be removed, and are removed, in my system. The



Cut No. 18. — Showing the principle of attachment of ordinary surface railway car bodies and trucks, the position of the wheels receiving the balanced load, and the flange to hold the train on the track. The kingbolt fastening car and truck together. Power being applied at arrow, the sliding-plate on left is fulcrum; the kingbolt is therefore incorrectly placed as strain-resister. I have removed this fault in my trucks.

instability of the track thus presented can be made more perfect. But before we show how it is done, let us examine the whole subject.

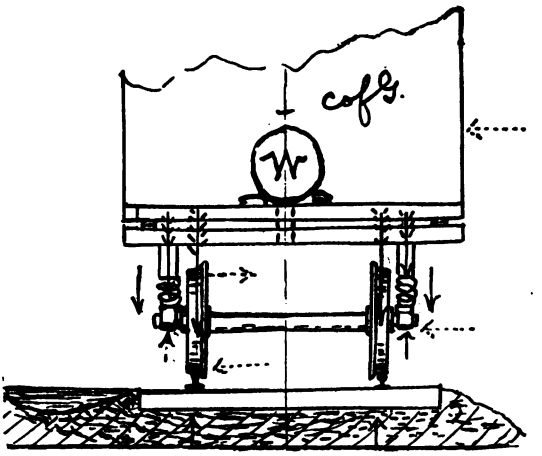
THE ORDINARY RAILWAY-TRUCK SYSTEM EXAMINED.

A pair of wheels is connected by an axle, — both fixed upon the axle, — which protrudes beyond their faces. Upon the protrusions boxes rest, and upon the boxes springs are placed, above which the top of the truck-frame comes, and this is attached to the car bottom by a kingbolt, around which the truck revolves, sliding upon plates laid between the car bottom and top of the truck for this purpose. This, with wheels in pairs, constitutes the ordinary truck and its attachment to the car floor. To consider properly, *two truisms* must be borne in mind: first, that a wheel, to be a proper support, must receive the load transmitted through it, at all times, by a thrust exactly at right angles to the bore of its axle-hole, as cut No. 18 shows; or, differently stated, the supporting part of the wheel must always stand at right angles to the thrust of the load superimposed. Second, that the load supported must be balanced. It will be noted also that the wheels remain upon the track by means of a flange; this flange is a source of very great cost and annoyance, which will be described at the time I show why I selected a right-angled grooved-faced wheel.

OTHER CAUSES OF COST.

The unbalanced loads, however produced: — by the sinking of the rail supported by an *untamped cross-tie;* by the

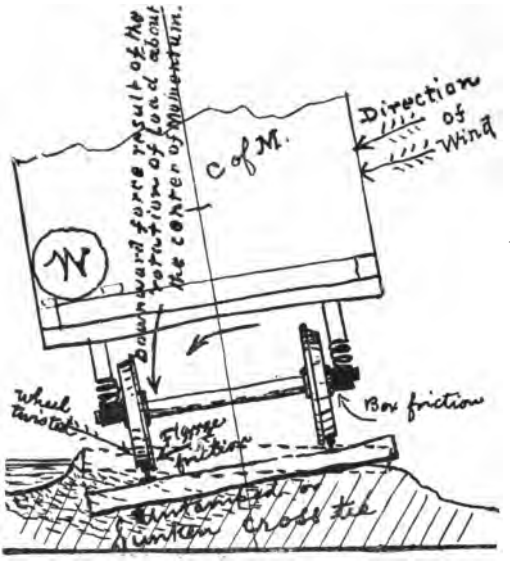
sinking of an under earth-supported tie, rendered unstable by wet or by *fresh thawed earth;* by *centrifugal action* in traversing curves; by *wind* driving the cars to one side over upon their flanges and by *downward pressures* produced by rotation of load; by *unbalanced load* of passengers or of freight in badly laden cars, or by *high centre of gravity*, —



Cut No. 19. — The surface railway. Its ditch. The seepage of water under the cross-tie. The pressure of balanced load shown by solid arrows, unbalanced loads shown to be incorrectly supported by the wheels, by dotted arrows. For sequel see cut No. 20. These faults entirely removed in the new system. Freezing of the moisture or seepage would cause heaving of track, and great danger to life and limb.

these and such faults are but increasers of resistance at the cost of power, adding more or less danger, and to the costs of increased wear and tear, and by not infrequent accidents, adding to these the cost of life, limb, and property. These things are well shown by the cuts.

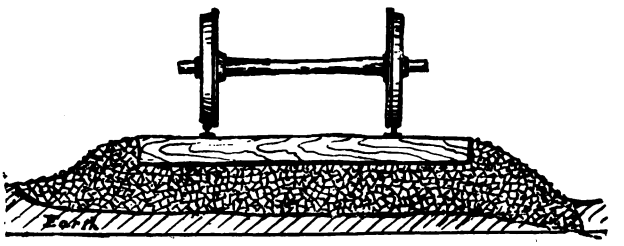
The trucks traversing even the best of such straight lines over a well-ballasted road have a



Cut No. 20.—The ditch. Showing seepage from it under cross-tie. Frost upheaval of cross-tie. Cross-tie beaten down by the force of the wind and the action of the load, or by either of those forces. Showing also the resultant frictions at flange and box. These are all removed in the new system.

ZIGZAG MOTION,

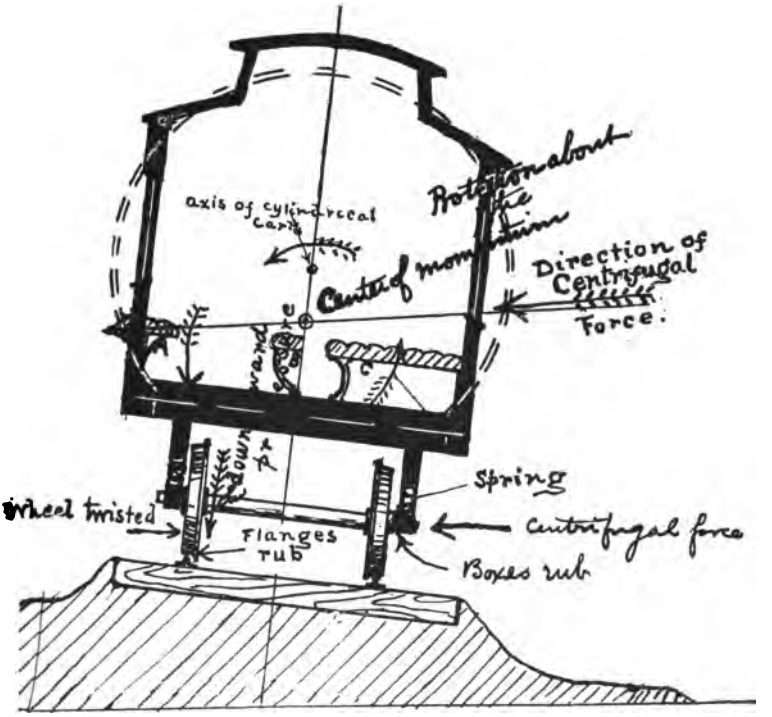
throwing the loads first to one side then to the other, straining the way, the rolling-stock, and the motive-power; this



This cut, No. 21, shows the method of securing a permanent way for ordinary surface railways, 18 inches of broken stone ballast beneath the cross-ties being required, all of which must be well ditched and drained. This way is more expensive than the Meigs Way.

motion being increased by the sinking of the way, by winds and unbalanced loads. My vertical way removes these difficulties and consequent costs.

When the car arrives AT THE CURVE on the surface railways, a different state of things takes place. The outer rail is raised so that the centrifugal force, influenced by gravity, causes the car to revolve around the centre of momentum, forces the outer wheel down upon the track, induces flange friction, box friction, axle friction, and a twisting upon the wheels, the downward force counteracting the centrifugal force, which is striving to cause the flange to mount the rail, and often it arrives at a point in dangerous proximity to the climax of mounting the rail altogether: sometimes it is derailment.



Cut No. 22. — This cut shows the trucks and car of an ordinary surface railway upon a curve, the arrows showing the directions of the strains developed. The dotted outline of a cylindrical car, its seats shown on the left half. On the right half is seen the seat of the ordinary car.

THE FLANGED WHEEL.

This flange in an ordinary railway represents the method by which safety is attained. The integrity of the flange and the integrity of the surface upon which it rolls are the underlying principles of safety. The flange is an element of weakness, inasmuch as it produces shearing frictions, twisting strains, and end frictions, which hereafter we will describe, as well as a long train of evils.

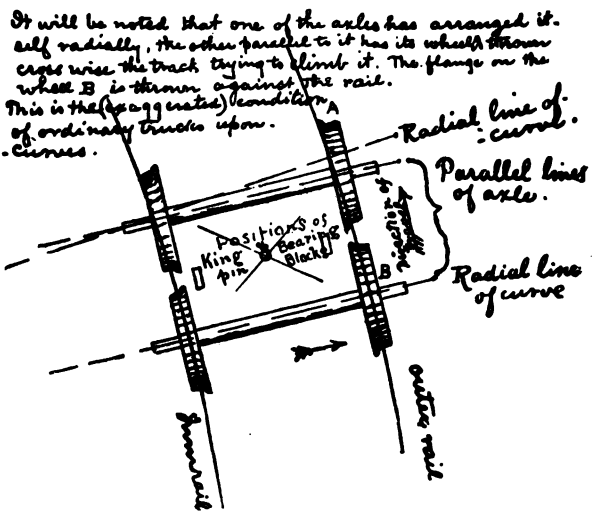
DRAGGING WHEELS.

The *inner wheels* traversing a shorter distance than the outer ones upon a curve, the wheels being both *fixed upon the axle*, the outer wheel, if it bear a greater load, and it generally does, than the inner wheel, "*must drag the inner wheel upon the track*"; but this is not true absolutely, because there are other conditions which must be borne in mind. The flanged wheel truck requires, to secure immunity from riding the rail, FIXED WHEELS upon a pair of PARALLEL AXLES. Such parallel axles cannot traverse curves without one and the other arriving at radiality, and I insert a sketch which makes this fact plain.

RADIALITY OF AXLE.

Both axles cannot assume a radial position at the same moment; one of them will obey the natural resultant of the forces; but as this would throw the outer wheels on the other axles somewhat crosswise the rail, abnormal frictions would ensue, and this wheel, mounting the rails slightly, would be increased in diameter at the bearing-point of its flange upon the rails, causing it to travel further than the other wheel

attached to its axle rolling upon its true face, a smaller diameter. This results in disturbing the centre of momentum, causing a zigzag motion of the trucks, crisscrossing the wheels and tracks, which, together with the increased downward force due to the rotation of the load around the centre of its momentum, presses downward the outer wheel upon


It will be noted that one of the axles has arranged itself radially, the other parallel to it has its wheels thrown cross wise the track trying to climb it. The flange on the wheel B is thrown against the rail.
This is the (aggravated) condition of ordinary trucks upon curves.
A
Radial line of curve.
Parallel lines of axle.
Positions of King pin
Bearing Blocks
B
Radial line of curve
Inner rail
Outer rail

Cut No. 23. — Showing the position of the ordinary parallel axles upon a curve. The lower axle has assumed a radial position; the other is necessarily parallel to it, and hence not a radial line. This crosses the wheel and rails, inducing frictions and causing danger to life and limb.

the outer RAISED rail, which increases this force; all being new frictions with attendant costs (see cut No. 22, p. 59), but serving to make the truck right itself upon the track, preventing the climbing of the rail by the crossed wheels. Thus the very fixity of the wheels upon the axles, although unbalancing the power and resistance and increasing the aggregate of friction, becomes the element of safety.

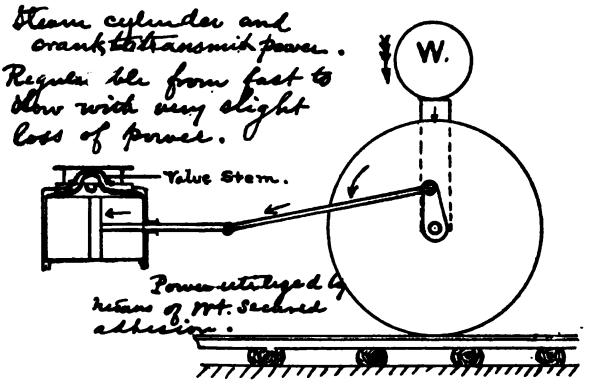
If all these faults can be got rid of by any means, it would be a matter of congratulation and a matter of vast importance to the whole people, because they are dangerous and add friction, which represents expense, reduces dividends, and causes high fares, which precludes the masses from riding. It must be seen that, if moisture and slipping were added to the other difficulties at the curve, it would be merely adding expense. And I will show, when I describe the substitutions I make for this state of things, that the whole of these difficulties are removed.

It is due, let me say here, to the removal of these abnormal frictions that my engine, as originally organized with a twelve-inch cylinder, provided with a rather deficient adhesion (purposely so made), could ever have mounted the curves, grades, and angles I prepared for it, especially in very bad weather, as shown by cuts Nos. 8 and 9 pp. 21 and 23.

ADHESION AND PISTON POWER.

And now, after this cursory review of the ordinary railroad practice, the question of the motive-power to be used presents itself; and it is well to state in the beginning that the present locomotive utilizes the power of the steam pressing upon its piston (tractive power) by the adhesion of its driving-wheels upon the rails due to the load superimposed, but weight-produced adhesion is rapidly lost by increase of grade and upon damp or bad tracks by speed; and that to utilize the power of a large cylinder a heavy load is necessary upon a dry, clean track; and nobody has been able to

substitute for this class of engine a better method of utilizing the motive-power of the cylinder than that due to adhesion produced by weight or load.[1]


Steam cylinder and crank to transmit power.
Regulable from fast to slow with very slight loss of power.
W.
Value Stem.
Power utilized by return of Wt. secured adhesion.

Cut No. 24. — This cut shows the ordinary practice of the direct use of steam as a motive-power, using weight to secure adhesion so as to utilize the pressure of the steam in the cylinder. It is easily governed from fast to slow without sensible loss of power. It is by this system of adhesion that all motors utilize their power practically.

BY COMPARISON ONLY CAN WE JUDGE.

Motive-power has been gained from several sources: —

1. The burning of coal to make steam to be used direct in a cylinder: Steam used at first cost.

2. The use of steam-charged water, the steam escaping upon relief of pressure, to be used direct in a cylinder, obviously at a loss: Second transmissions.

3. The use of steam in connection with soda, obviously at a loss: Second transmissions.

[1] Adhesive power of locomotive per ton of load on driving-wheels.

When rails are dry	600 lbs.
When rails are wet	550 lbs.
When rails are damp	450 lbs.
Foggy weather	300 lbs,
Icy or snowy weather	200 lbs.

4. The use of steam in a cylinder or water-power: — (1) to make power; (2) to run a dynamo to make electricity; (3) distantly transmitted by wire; (4) to run another dynamo; (5) to run a driving-wheel; or in all, five transmissions, obviously at a loss.

5. Steam to compress air to be used in other cylinders like steam, obviously at a loss: Transmissions.

6. Steam to draw a cable of indefinite length, obviously at a loss: Transmissions.

7. Electricity made by a battery, used by a motor to run a driving-wheel: Direct.

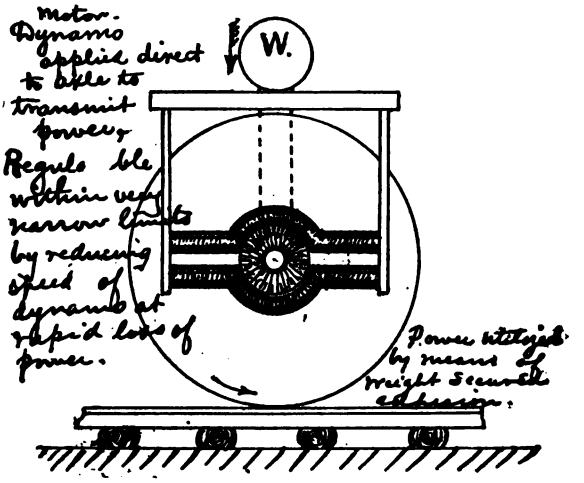
8. Electricity made by steam or water power and stored to run a motor, to run a driving-wheel: Five transmissions, obviously at a loss.

These comprise the whole of the practical means, except horses, by which men have carried on their transportation. And as it will be seen that steam or water power must be used to make any of them effective, except the battery, they are all roundabout methods of using steam or water power, and involve transmissions of power. TRANSMISSIONS OF POWER CANNOT BE MADE WITHOUT LOSS. Thus I decided that unless the gain is sufficiently great as a luxury, an engineer would not be warranted in using a more expensive method, and it would be sheer nonsense for me to make any other statement unless I were merely engaged in a catch-as-catch-can transaction.

Because my way and truck system, with its safety and elevation above the earth, together with the great body of metal in the way,

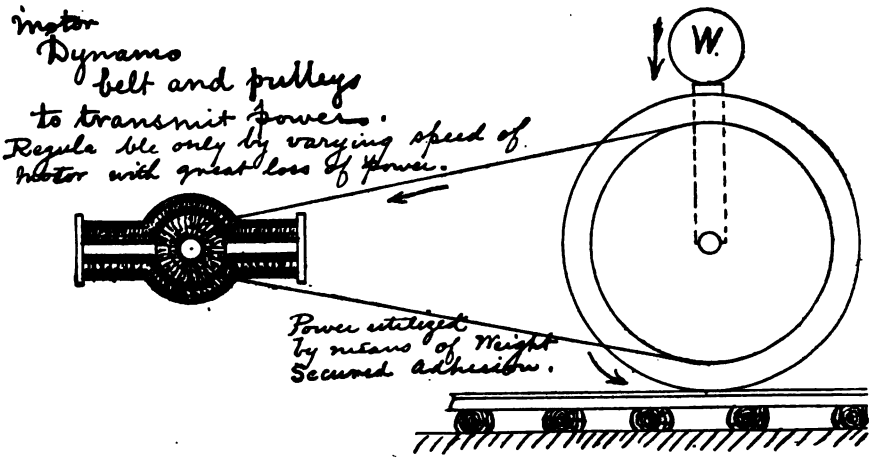
OFFERS UNUSUAL ADVANTAGES FOR THE USE OF ELECTRICITY,

I have looked forward with hope that somebody would present a slow-running motor, so governable as not to lose power by reducing speed, so that the difficulties of practical application, which must be added to that of loss of power,

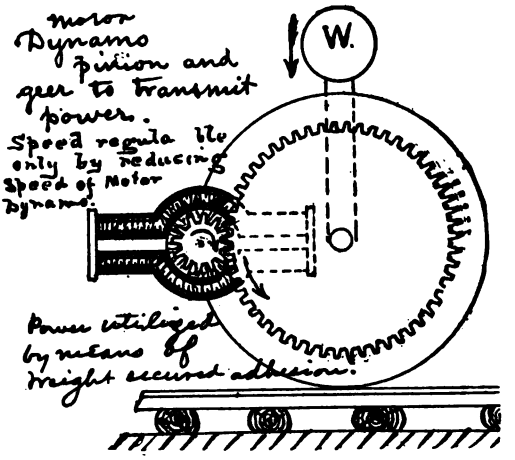


Cut No. 25. — This cut shows the application of electricity by means of a motor attached to the axle of the driving-wheel, adhesion being secured by weight. It has none of the salient advantages of regulation without serious loss of power which the steam cylinder possesses.

might disappear, warranting the luxury of the use of electricity even though it cost more. The cuts I am about to present will show so clearly the faults of the practical application of electricity to great motors, that argument is not needed in relation to them to show why I did not, and why no great *traffic* road has used, or can use, them.



Cut No. 26. — This cut shows a method of applying electricity by belt-power. Speed is reduced by running from a small pulley on the motor to a large one on the driver. Regulation of speed can only be secured by slipping of wheel or belt or at a loss of power. Adhesion is secured by weight. It has none of the salient advantages of the steam-engine as to regulation of speed without sensible loss of power.



Cut No. 27. — This cut shows a mode of reducing the high speed of the electric motor by a small pinion running a large one. Regulation of speed can only be secured by slipping of wheel or loss of power. Adhesion secured by superimposed weight over drivers. It contains none of the salient advantages of steam to regulate power and speed without sensible loss of power.

There is one other method used, that of a worm and gear, the regulability of which is at the same disadvantage.

GREAT CYLINDERS AND POWERS REQUIRED.

No one has discovered a means practically to transmit the vast power required to run a great number of trains, say fifteen, with 1,500 horse-power for each engine, all being in commission on a seven-mile double-track road at the same moment; there would be required 22,500 horse-power — a power greater than that developed at Lowell by the whole Merrimack River.

None of the dynamo motors begins to present power enough practically to take the place of a 16 x 22 in., much less that of an 18 x 24 in. or 20 x 24 in., cylindered engine. Engines of these sizes are found to be absolutely necessary to pull the trains required on the surface steam-roads.

I am not talking about toys or village railroads. I am striving to present a system of railway with which we will be able at less cost for way or power, and with fewer cars run at higher speed, not dependent for safety upon the good luck of keeping the rail, to carry many more than 115,000,000 of passengers in a year, as did the New York elevated railroads last year, reaching, it is said, their full capacity of carriage only by running their trains with but a slight interval: therefore, as the many recent accidents have shown, with great dangers and no longer as a rapid transit.

THE FUTURE.

I desire to present a system which will increase the interval between trains and make it safe to increase the speed; lessening the danger; running at less cost, with greater economy in wear and tear; which provides proper prepara-

tions for carrying the vast number of people which the future will call for, if the rate of increase of carriage is the same in the future as it has been in the past.

DANGERS OF TRAVEL.

Upon thinking of the dangers inherent in a track lying upon the surface of the earth, and the increased danger when derailment occurs when it is elevated eighteen feet, those which I have described as inherent in the way itself and those coming from outside sources, such as derailments of cars running upon parallel tracks, running off and into passing trains, obstructions, crossings, frogs, and switches, and, as I have before said, the integrity of the rail and the integrity of the wheel being necessary to make available the slight flange of the wheel to hold the train upon the track, —

A PERFECT WAY SUGGESTED.

— I concluded that a way should be post-supported, and that the trucks, and not the cars, should straddle that way; the way for very heavy trains being itself at least half as high as the wall of the car, thus reducing leverages; and, by —

THE REMEDY OF THE EVILS.

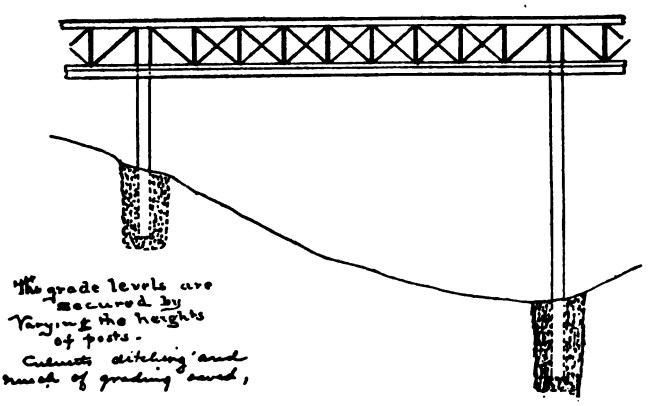
(See cuts Numbers 14, 15, and 16, pp. 37 and 39.)

— inspecting the two things side by side, the incomparable safety against derailment of my truck-frame astride of the way forty-eight inches down, as compared with the flanged wheel one inch on, as is the case with the ordinary railway, is seen at a glance.

I present here a side-view of my system of track, or way, as used in crossing the earth not level.

IS THE REMEDY SAFE?

It will be seen by a slight inspection that if strains were presented so as to push the way over sideways, it must pull not only the immediately contiguous post over and outward to which the way is attached, but that, by reason of the continuity of this way, all other posts in the whole line must be pulled down or the way pulled in two, as shown by cut No. 30, which well illustrates the resultants of centrifugal or wind strains upon the way. The truck-frame is made strong enough to resist these strains.



Cut No. 28.—Skeleton side-view of Meigs Way, illustrating the method of securing grade levels, and of avoiding filling and leaving the waterway open, being secure against washouts and consequent loss of life.

I have thus presented the reason for the great security and absence of vibration, proved by the violent tests I have made at East Cambridge.

Of course the application of this system could be to smaller cars than those which I have built, using a lighter way, which would be very useful for a country-town rail-

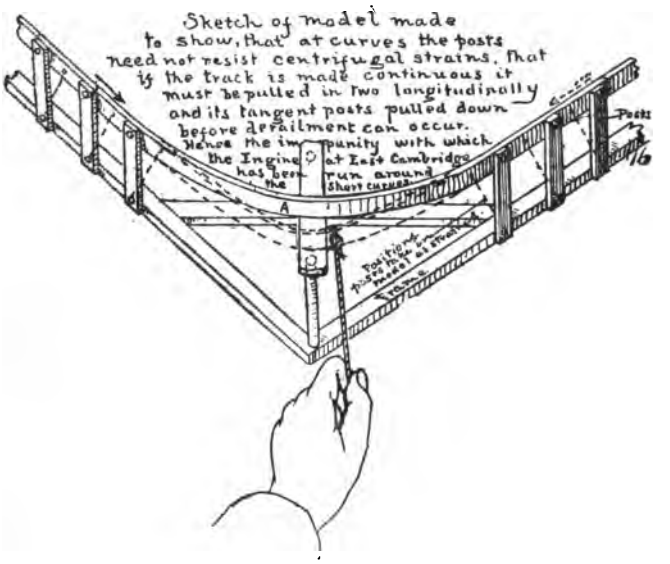
way or a special suburban way. We have not yet made the drawings for the way and engines required for these uses, but will do so after our present road is built. But if we use small cars with a lighter way for a heavy traffic, they must be run slowly and in greater numbers to render the service required. This done, the passengers would be greatly crowded and inconvenienced, and the management left unable to carry the people at times of increased travel.

I run the load upon the lower part of the girder; thereby lowering the centre of gravity very greatly, concentrating and reducing the strains as well as the cost, so that my system of road is *adapted for use across the country* and for very high-speed trains.

SPEEDS THAT ARE POSSIBLE PRACTICALLY.

As upon the New York Central Railway, where trains are held on the track by an inch flange, a speed of 73 miles an hour for a run of 11 miles, and of 74 miles an hour for a run of 12.8 miles, and of 71 miles an hour for a run of 15.77 miles, or 86 miles at 67.27 miles per hour, has been accomplished; upon my plan, derailment being impossible, 100 miles per hour continuously is possible, engines and way being built especially for speed. I am warranted by the results of our experiments at East Cambridge in saying all of this without going so far in my assumption as I did when I built the tortuous track in advance of the completion of the engine to be used upon it, all of which came out as contemplated. It is as certain that all these things can be done as it is that a hook-and-line made for codfishing, and successfully used, points out that a hook-and-line can be made to act equally

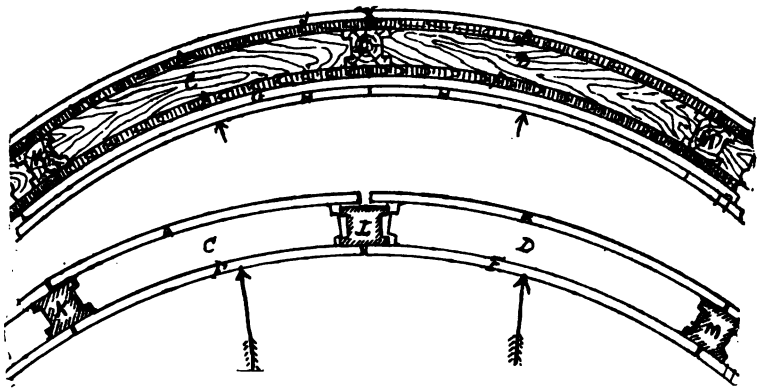
certain in taking a shark. For we have in our experiments at East Cambridge taken the shark with the cod-line and hook many, many times. And having broken our line or hook at times in our experiments, I have simply replaced them as well as I could with those suited to the purpose. Thus we have ended the difficulties. It was for this purpose that the Legislature required our experiments, and for this purpose that I bunched every known difficulty. No unprejudiced engineer can see these things and examine them without being convinced that the thing is done; to show how it is done *the whole detail will be unfolded and illustrated.*



Cut No. 29.—One of my illustrative models to show the immense strength of the new way properly constructed. That centrifugal forces at curves must pull the way in two longitudinally before derailment can take place, involving the pulling down of the contiguous lines of posts.

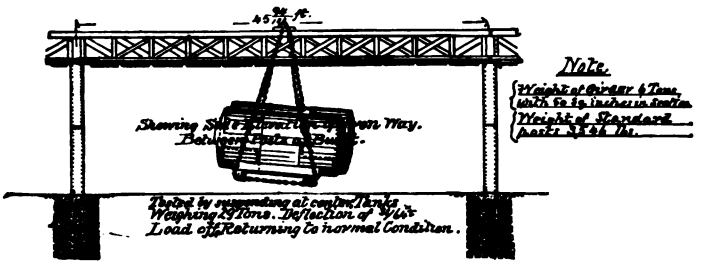
THE TRACKS AT A CURVE SHOWN TO BE VERY STRONG.

AT A CURVE for my way it has been supposed that great strength of posts would be required, but I did not think so, and my experience proves that they are not required, because at a curve the centrifugal action tries to burst through the way; and I have made a model, of which a sketch is here inserted, which shows that a strain like a centrifugal one would have to pull down in the lines of way the contiguous posts which are tangent to the curve, before it could burst through the track, so as to turn the supporting posts over. It must pull the way in two longitudinally, which would hardly occur in practice if the way were properly designed with regard to the service which it might be called upon to endure. But to make this still plainer I have made an additional illustration representing the top chord of our way, in which posts K, L, M are connected by stiffeners C and D and tied



Cut No. 30. — One of my illustrative models showing that centrifugal forces or side-pressures must pull the way in two longitudinally to derail the train.

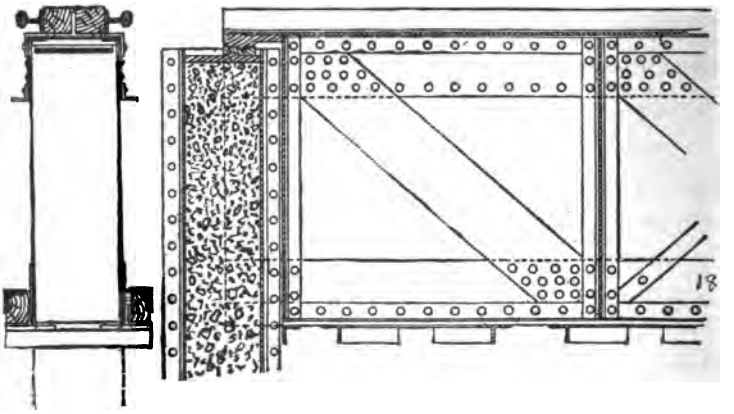
together by the face tie-pieces or stringers A and B and F and G and H. As shown in the lowesr sketch, parts of these tie-pieces are left off and the centrifugal strains of a car and its trucks are represented by arrows, which have forced the post L outward from its normal position, but it will be seen that, before it could be forced outward in the direction of the arrow, the pieces A and B and F and F must be separated from each other or pulled asunder, parted if continuous. A model I have illustrates this very clearly. These tie-pieces and the rails facing them in the test tracks at East Cambridge are *many, many times stronger* than the pull even of THE MOMENTUM OF A THIRTY-TON ENGINE concentrated upon a nine-foot nine-inch wheel base, when run at a very high speed against them, as we have proved. This is the reason why this railway becomes, so far as the way is concerned, AS SAFE AT A CURVE AS ELSEWHERE in the line of the way, and it is a matter of congratulation that my experiments have proved that loss of life or limb will never occur from ditching the train at curves. The lower or load-supporting boom is made upon the same principle, but is much stronger; thus, the way upon straight line and curve is vastly more perfect than that of the ordinary railway. The way we have built as constructed in iron, as proportioned and laid to resist the strains we have put upon it, has been calculated by every known rule worth using, by my brother, James L. Meigs, and is well illustrated in this sketch. It has less iron than the girders for the New York system, and yet it is so disposed as to sustain double the loads when applied to the same space — this too with a greater margin of safety.



Cut No. 31. — Shows a test of girder which was made a year ago, before the wood was added. Twenty-nine tons load; deflection less than half inch. Safe beyond any possible requirement for freight or cars seating 125 people. (See cuts Nos. 34, 62, 63.)

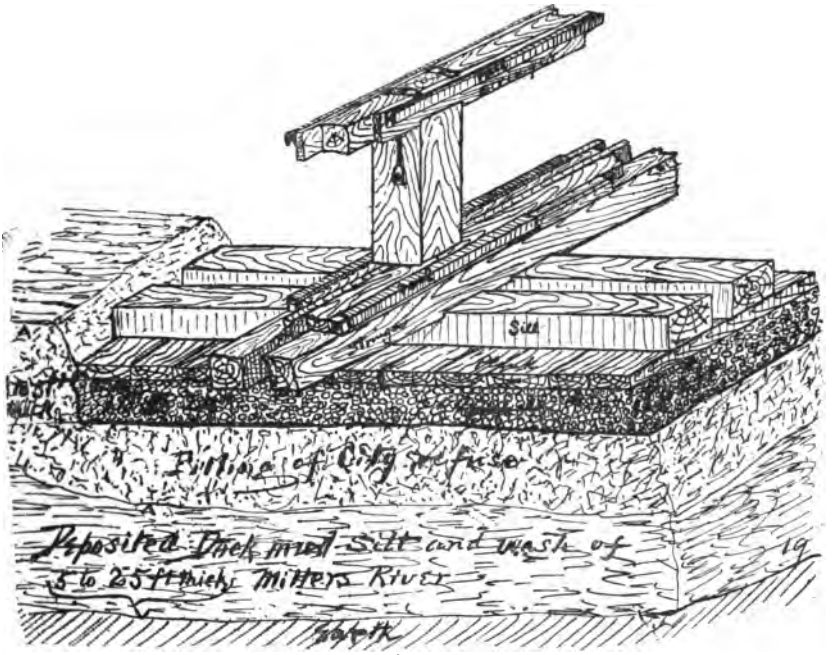
POST-FILLING AND NOT THE POST SUSTAINS THE LOAD.

The posts themselves were filled with as dry concrete as could well be used, and tamped in from bottom to top of post. Upon this concrete at the top of the post rests the load and girder-way, upon an iron plate supported by another plate, so that the shell of the post does not support the load



Cut No. 32. — Showing post-filling and girder resting upon concrete in posts; thus securing the whole strength of posts for emergencies.

at all, except by the friction of the concrete as against the walls of the post — thus contraction, expansion, alignment, and sudden shock are all provided for, and safety of support beyond anything heretofore known is secured.



Cut No. 33. — Wooden way as set over the dock-mud of Miller's River. The security presented by this method of post-setting has been demonstrated at East Cambridge in the most satisfactory manner.

TRACKS MADE STABLE OVER DOCK-MUD.

The methods adopted to give stability to the tracks located over dock-mud which underlies them are of two kinds, based upon the experience of Mr. James L. Meigs, as engineer of various railways in the valley of the Mississippi River.

Under the wooden way holes about ten feet long by four feet wide were scooped out to depths varying from one to three feet. Into these he dumped clean gravel well tamped in by the ordinary hand-maul, and leveled. Upon this surface was laid ordinary planking of four-foot lengths. These were mauled to an exact level. Upon them were laid at right angles to the line of the way ten-foot sills in pairs. Between these were notched the posts. These holes were prepared every eleven feet for the fifty-foot curve; the posts set vary in height to suit the place and grade.

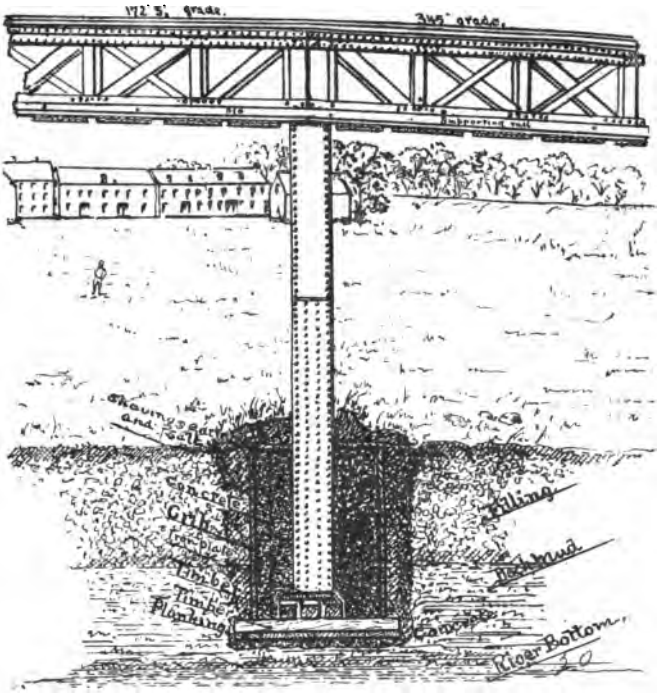
Running along the tops of these posts, notched into their faces and bolted to them, are stringers faced with rails upon which tying-down and balancing-wheels run; stiffeners between these stringers connect post and post, and are tied down by face-bolts, while at the bottom other stringers run longitudinally, which are cross-bolted, and faced with corner rails, all tying the whole securely together. Upon these lower or corner rails the load is carried, the supporting-wheels running upon them. All of this is shown very clearly by the cut.

The way has *behaved so very cleverly* at the trial at East Cambridge that it is often remarked that a cart rolling over the stones of the paved Bridge Street disturbs the earth more than does the roll of our 30-ton engine over the horseshoe fifty-foot curve and up the sharp grade upon that curve, pulling a heavy train after it at considerable speed.

The posts of the iron way were sunk into the earth a distance of about six feet, and rest upon sills supported by planking resting upon concrete from two to six inches thick. This is clearly shown by the cut, which is a sketch from a

photograph of a post at an angular junction of the way, the artist adding in the sketch the post-settings.

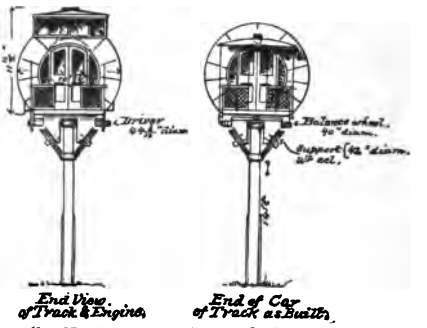
As the posts were set in December to prove the practicability of doing it at that season, they were surrounded by cribs of wood about five feet square, extending nearly to the surface of the earth. It was necessary to use powerful pumps to keep out the encroachments of the sea; when the tide was in, it arose within fourteen inches of the surface, and as the



Cut No. 34.—Post and post-settings of Meigs Railway as built at East Cambridge, Mass. Located over and in the dock-mud of Miller's River, showing angular or knuckle jointure of the grades or abrupt change of grade at posts, 345 ft. grade to 172.5 ft. These faults were made to break or prove the engine. No ordinary locomotive could possibly pass such a fault and live, yet ours does it well.

pump-water froze almost as soon as it touched the earth, the difficulty of filling the cribs with concrete and surrounding them with the earth, which was wetted and tamped in, can well be imagined. To give the concrete an opportunity to set without freezing after the holes were completely filled, the bases of the posts were surrounded with a mixture of shavings, earth, and spent salt.

The sections of the iron way have upon their upper and lower outer faces wooden pieces which run in grooves in longitudinal directions, tying the structure from end to end, connecting all posts and carrying upon their faces the iron rails upon which the wheels run, pressing them inwardly and toward each other, presenting *a continuously even and evenly supported rail surface* (not broken like the cross-tie support of ordinary rails); the rails are thus cushioned, so that there are no shock vibrations of the wheels transmitted to the iron of the way. (We can safely run, therefore, as we have done purposely at East Cambridge, for many months, over a rail in a shattered condition.) This *deadening of the vibrations* prevents loosening of bolts and nuts and prevents the disintegrating influences of the roll and jar of train. The rails still further add to the strength of the way, holding and tying the structure together, and if we liken the results obtained to

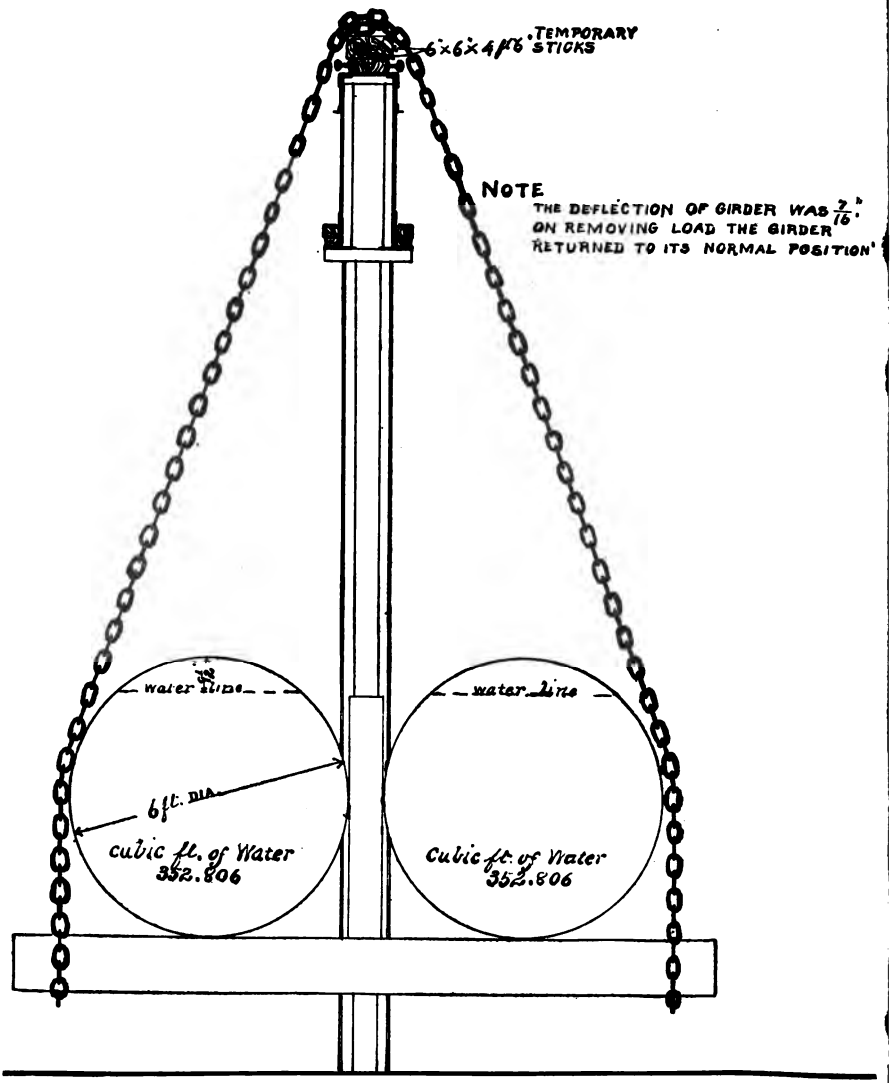


Cut No. 35. — Showing end views, with other details, of Meigs Way.

ropes tied to and stretched from post to post with side-pressures brought to bear upon the ropes, the force exerted would tend to pull the posts down; but if the line of posts were stronger than the ropes, each post being sustained by the other posts tied to it, then the stretched ropes as pushed sideways to be broken must be pulled in two longitudinally. Thus the way straddled so deep down by its truck is seen to be immensely safer and stronger than any other.

WE HAVE TESTED IT IN MANY VERY SEVERE WAYS.

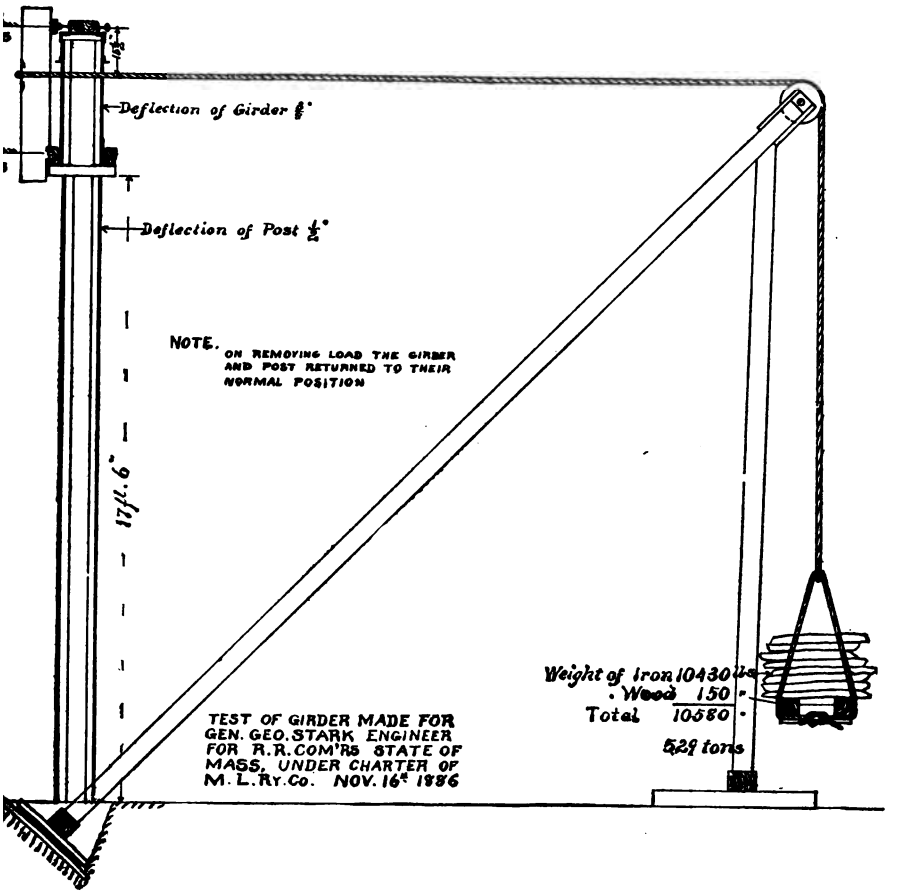
One of the sections of the iron way (the end one) mounted in place, eighteen feet above the earth's surface at its lowest point, with a span of 45.94 feet, had swung from it at its exact middle (before the wood was added) two large rendering-tanks which were filled with water, so that a load of twenty-nine tons was brought upon the exact centre of the way with a deflection of little less than one-half inch (see cut No. 31, p. 74), returning to the normal condition after the load was taken off, although this was many times repeated. The *same* test, with a little greater load, to wit, 60,187 pounds, was made for General Stark's official test, and was also photographed, from which cut No. 62 was drawn. THIS LOAD TEST gave a deflection of seven sixteenths of an inch, the girder or section of the way returning to the normal position after the removal of the load; this was many times repeated with prolonged applications of load with like result. The stringer irons in these sections of the way are of unbroken lengths, as long as the girder itself. The girders were built to stand the heaviest loaded trains known. These load tests are laid



Cut No. 36. — Weight of tanks	11,980	lbs.
,, water	44,030	,,
,, chain	1,997.5	,,
,, timbers	2,180	,,
Total	60,187.5	

Test of girder made for General George Stark, Engineer for Railroad Commissioners State of Massachusetts, under charter of Meigs Elevated Railroad. November 16, 1886. (See cuts Nos. 31 and 62.)

February 18, 1887. A wind storm of 60 miles per hour blew bodily from the tracks of the Denver and Rio Grande Railway, two sleepers, two passenger-coaches, a baggage and mail car — the latter two being burned. A freight-train of 20 cars on a sideing was also derailed by the wind. — *Boston Transcript.*


Deflection of Girder ⅛"
Deflection of Post ½"
NOTE. ON REMOVING LOAD THE GIRDER AND POST RETURNED TO THEIR NORMAL POSITION
17 ft. 6"
Weight of Iron 10430 lbs
Wood 150 "
Total 10580 "
5.29 tons
TEST OF GIRDER MADE FOR GEN. GEO. STARK ENGINEER FOR R.R. COM'RS STATE OF MASS, UNDER CHARTER OF M. L. RY. Co. NOV. 16th 1886

Cut No. 37. — This sketch gives the results and figures of a wind test blowing 33 pounds per square foot, or 110 miles an hour, increased by double unbalanced load of passengers, acting on the walls, tracks, and floors of a train, plus twenty per cent. Deflections trifling and harmless. An ordinary train would be picked up bodily and tumbled over.

upon the assumption that nearly double the number of pounds per lineal foot could be put upon our girders than that laid for the strength of the New York system. The test for the New York girders being 33,330 pounds suspended at the centre of the way, we suspended 60,000 pounds, keeping our factor of safety very high; and yet our single girder-way weighs less than the New York double one. Therefore if we so desired, larger cars could be used, reducing the dead-weight per passenger, when carrying 125 people each, to as little as that carried by the lightest buggy. This change was made because I did not consider the cars of the New York system large enough to meet the requirement of RAPID TRANSIT.

WIND TEST: A HURRICANE'S PRESSURE USED.

Besides these tests General Stark desired a wind test, because with a post-supported railway it is necessary to design it to meet the strains which may be brought upon it by winds, the greatest of which would be that brought to bear by a hurricane blowing against the wall of a train. My brother calculated the wind-area of a train, its trucks, car walls, and of the way itself, placing the trains so as to do the greatest damage, the cars doubly laden and unbalanced. Then taking one of our girders and placing a stick on the back side of the girder and putting ropes about the stick at that point which would give the resultant of the twisting force of the wind blowing athwart the train as it would be applied to the girder through the trucks astride of the track, the end of the rope was carried over a skid and pulley and loaded with a weight *equivalent to the force of a wind blowing 110 miles an hour*, or a hurricane, which, accord-

ing to Didion and Baker, the best authorities, is said to be thirty-three pounds per square foot. This was increased twenty per cent. We got the very slight deflection of this marvelous girder of but three eighths of an inch, while the posts were deflected one-half inch, girder and posts instantly returning to their normal positions after the removal of the load. This was repeated several times: once the load was left on all night. These tests always gave the same result: the way returned to its normal condition. This test proves my way and train to be wind-proof. (See cut 63, p. 144.)

THE EARTH PROBED BY HAND.

While this experiment was in progress, I took a five-eighths inch iron rod lying on the ground near by, of twelve feet in length, and by hand started it into the foot-hole (about sixteen inches deep), against which the skid rested, when one of the men ran it down by hand without the slightest effort until its end was a foot below the surface of the earth; thus, it was put down thirteen feet in the soil, through the filling and into the dock-mud in which the posts of the way just tested are set. This penetration was made within a few feet of one of the posts supporting the girder tested.

But there is a TEST AT EAST CAMBRIDGE FAR BEYOND THIS WIND-STRAIN even, occurring every time the way is used. The iron girders at tangency to the fifty-foot radiused curve upon the 345-foot grade deflect at nearly right angles to the line of approach and are upon the same grade of 345 feet to the mile; now if you will consider the momentum of the engine and the resistance due to the transfer of the direction of the movement of the load, together with the

approach of the engine up the high grade with its boiler sixty inches in diameter, its centre seventy-nine and three-quarters inches above the top of the track, and its machinery, in all weighing thirty tons, followed up by the momentum of the train when run upon this curve at a comparatively high rate of speed, thirty miles an hour upon several occasions, it will make a test of these girders upon and tangent to the curve far beyond the actual practice which could be required in the city, or for that matter elsewhere. No service of this kind could ever be placed upon the way, and this track is thus amply tested.

An ordinary observer cannot comprehend the severity of these tests when he sees it, and in fact men reputed to be high in the art of engineering have seen its accomplishments but have failed to comprehend it, due, I have no doubt, to the incapability of the mind to grasp at one moment a multiplicity of things seen. If they had ridden over an ordinary road with nothing abnormal in it, but the approach to this high grade, a series of dished angles breaking every eleven feet from level to a 60-foot grade to 120 to 180 to 240 to 300 to 345 feet, no one of them, more than likely, would have been here to tell the tale. It would have destroyed the engine and derailed the train. I purposely took a party of engineers up this grade and curve at thirty miles an hour. Their faces were wreathed in smiles and nobody seemed to have any fear. I believe this test a more severe one, and more trying than the hurricane wind test, yet it has been used in this way an innumerable number of times.

THE HIGH WIND TEST was made not especially to prove the way as strain proof against a hurricane wind, but

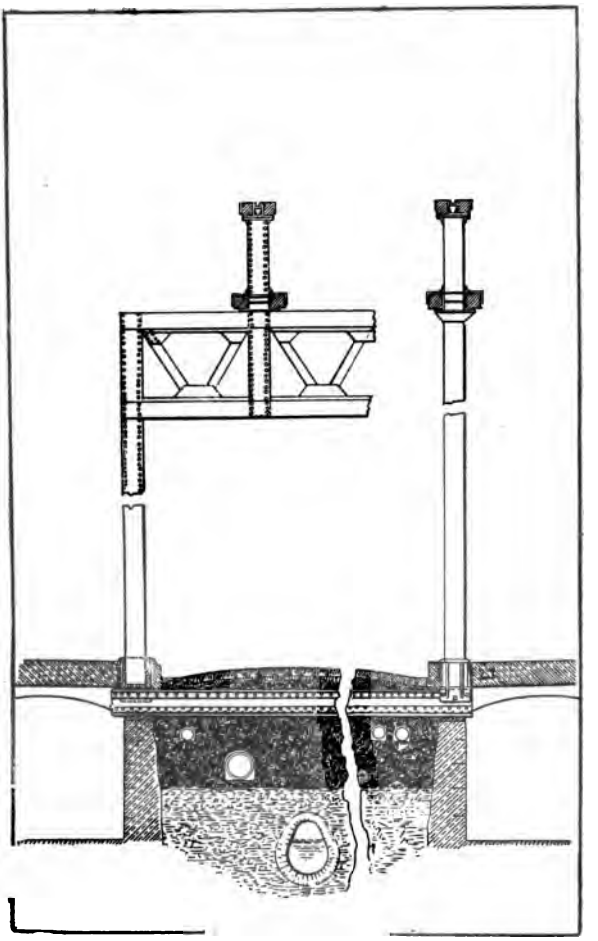
to show that our way was vastly safer than any ordinary railway as against wind, nay, absolutely safe, for ordinary cars subjected to such a wind would be carried bodily away, engine and all, but the test was made more particularly to show that our way was strong enough to take any length of car we might desire to use without fear of wind, and that if the curves of the city can be kept under eighty feet radius a car seventy-five feet long, seating 126 people, can be used. This fact is of vast importance in settling the problem of the carriage of large numbers of people and wholly consistent with a true solution of the difficulties of city, and in fact of all, transportation of men, giving the least dead-weight per passenger and consequently the least weight to stop and start and the least to create momentum, reducing the dangers of collision.

THE SIDE STRAINS brought to bear upon the girder, next and adjacent to the curve under these trials, is an exhibition of the strength of the structure which would warrant the use of such a car. Thus it is made clear that if proper attention is paid to the construction of the girder in regard to the strains that are to be put upon it, by the centrifugal and momentum force of the engine when it arrives at a curve, the strain could not be thrown on the post until the track had been stretched or pulled in two longitudinally, and it is alone owing to this fact that at East Cambridge we have been enabled to run our engine, tender, and car around these curves with impunity. (See cuts Nos. 29 and 30, pp. 71 and 72.)

THE WOODEN WAY TESTED.

While the iron way has been tested in these extraordinary manners, the wooden way has been tried by momentum and

loads sufficiently to show that it can stand every kind of use. Our experiments show that the wooden way must be made, however, upon the assumption of a higher factor of safety, on



Cut No. 38. — Post-settings upon cross-girder, beneath street, embedded in hydraulic cement, with passageways left for pipings, showing how expensive foundations and cellars are be avoided. Also, showing a sidewalk way and a post-supported way upon cross-girders.

account of its more yielding nature, if such extreme tests are to be applied.

POST-SETTINGS IN STREETS OVER BAD GROUNDS, CELLARS, AND PIPES. — NO DISTURBANCE.

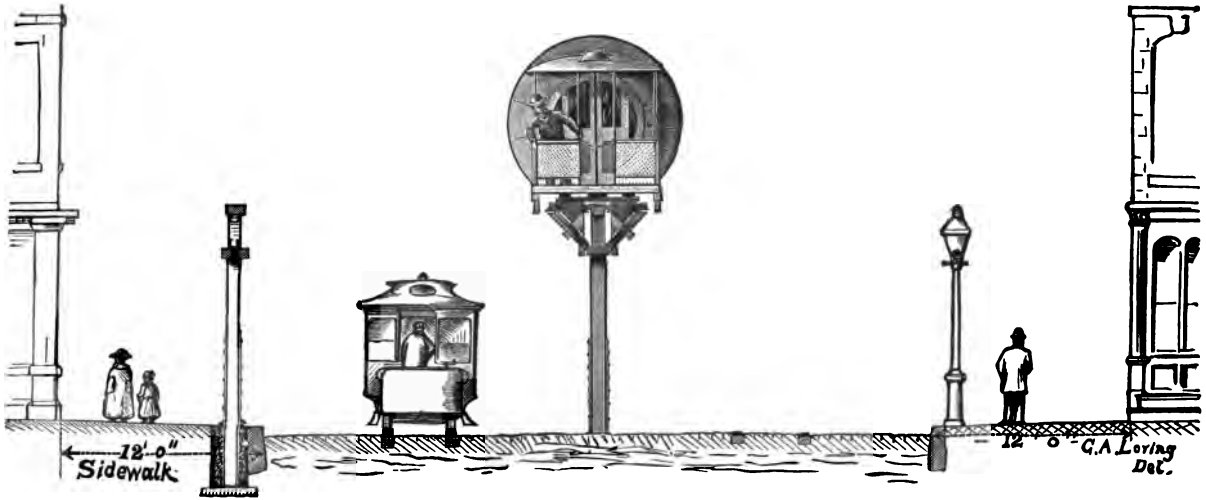
In a city we might have to go through such a street as "Devonshire," in Boston (about which street a committee of the Legislature called upon me for figures), filled with pipes and sewers, and cellars filled with boilers, extending under the sidewalk. I show how both sideway and cross-girder supported way might be laid without interfering with the pipes, and securely, no matter how bad the bottom might be. It is clearly shown by the cut on page 86.

THE NEW DEPARTURE.

Thus you have seen that in my system of railway the whole order of things is changed. The way, or track, instead of lying upon the earth's surface subjected to its moistures, frosts, and snows, is turned up vertically and post-supported; the posts held in a vertical position by proper settings in the earth's surface.

NO DISTURBANCE TO LIGHT AND AIR OR TO COMFORT.

We have built our way at East Cambridge within eight feet of the windows of a frame-dwelling, and it was declared by the woman living in the house, and was seen to be true by my inspecting directors, Messrs. William S. Butler and W. W. Kimball, who visited the house, that, during the passage of our train at all speeds, "she was less disturbed by the passage of our engine than by the horse-cars in the street." In fact,



Cut No. 89.—Cross-section of a street, showing that the Meigs Railway does not disturb light and air; that it presents the least cross-section of any railway, and that its trucks, astride of the track 48 inches, render its cars absolutely safe against derailment, even at a moment of collision. The track is an open post-supported girder, 17½ in. x 22½ in. at its widest part overhead, and but 50 inches in depth.

although the window was open, the approach of the train could not be told until it had got opposite the window.

IT IS SELF-EVIDENT

to anybody who inspects it, THAT LIGHT AND AIR ARE NOT AT ALL INTERFERED WITH.

I insert (on pages 90 and 91) two maps of New York City which prove beyond a doubt that property in New York adjacent to and near elevated roads has been raised in value, and I assert that rents are surer and better everywhere, even where the street was fully covered over by the way used, that of 4 ft. 8½ in. gauge, making cellars of the first floors, as my way cannot do; and I call your attention to the fact that property distant from the railway was not increased in value in proportion to that near the elevated railway. I trust you will read the appended letter which my treasurer, Mr. William S. Butler, obtained for me, and which I prepared to send out as a circular of information.

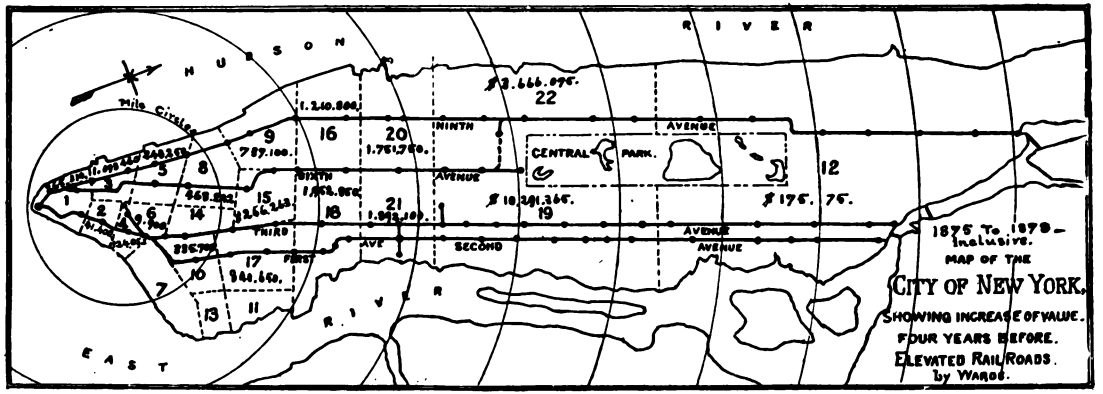
"*To the people of Boston*, — An objection to elevated roads in Boston, put forward with every assurance of truth, is 'that any system of elevated railroads built in Boston for the convenience of the people would destroy in great part the value of real estate and business along the lines where said roads might be built.' Two gentlemen, in their testimony at the Street Railroad Committee's hearing upon my petition, asserted solemnly that by the building and operating of elevated railways in New York real estate and business along the line of the roads was 'depreciated' and 'utterly

INCREASE OF VALUES IN WARDS MOST TRAVERSED BY ELEVATED RAILROADS.

WARDS.			Increase of Values during Four Years previous to Opening of Roads, 1875 to 1878, inclusive.	Increase of Values during Four Years following Opening of Roads, 1879 to 1882, inclusive.	Excess of Increase of latter period over former.
No.	Extent of Territory.	Traversed by what Lines.			
1	All the territory South of Liberty st. to Battery.	Third, Sixth, and Ninth ave. Lines.	$265,310	$9,516,664	$9,251,354
12	All the territory North of 86th st. on both sides of Park, to Harlem River.	Second, Third, and Eighth ave. Lines.	$175,175	$31,783,374	$31,608,199
19	North of 42d st., East of Sixth ave. and Park, to 86th st.	Second, Third, and Sixth ave. Lines.	$10,291,365	$53,245,643	$42,954,278

INCREASE OF VALUES IN WARDS NOT TRAVERSED BY ELEVATED RAILROADS.

WARDS.		Increase of Values during Four Years previous to Opening of Roads, 1875 to 1878, inclusive.	Increase of Values during Four Years following Opening of Roads, 1879 to 1882, inclusive.	Remarks.
No.	Extent of Territory.			
7	East of Catharine st., and bordering East River.	$186,750	$279,558	Property Appreciating.
11	Between Houston st. and East Fourteenth, bordering East River.	$823,020	$375,743	Property Depreciating.
13	Between Grand and Rivington sts., and bordering East River.	$231,450	$211,650	Property Depreciating.

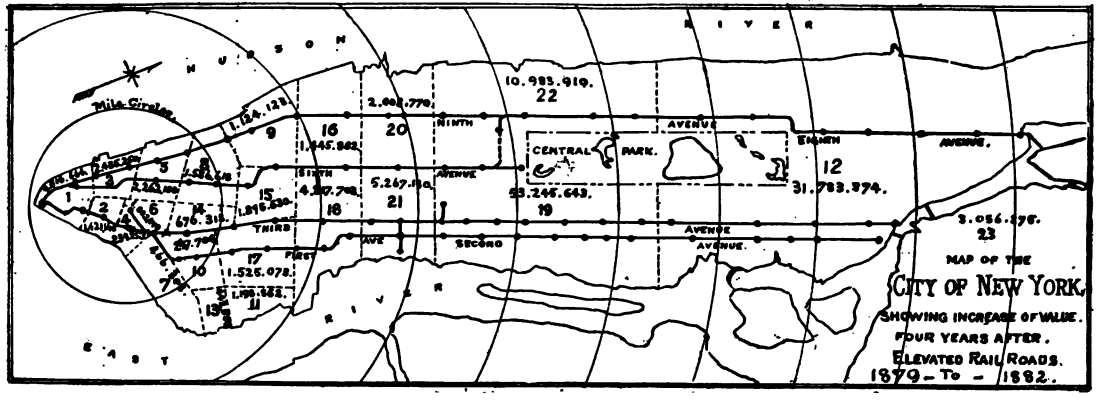


Cut No. 40.—But, again, the several wards in New York City have been benefited in proportion to their proximity to the elevated roads, as may be seen at a glance from the following tabular statements.

This principle has been further proved in after years, and a property-holder who does not seek the proximity of elevated roads to his possessions is foolish.

GENERAL TABLE SHOWING INCREASE OF VALUES IN WARDS TRAVERSED BY ELEVATED RAILROADS.

WARDS.	Increase of values during four years previous to Opening of Roads, 1875 to 1878, inclusive.	Increase of values during four years following Opening of Roads, 1879 to 1882, inclusive.	Excess of last four years over first four.	Excess of first four years over last four.	WARDS.	Increase of values during four years previous to Opening of Roads, 1875 to 1878, inclusive.	Increase of values during four years following Opening of Roads, 1879 to 1882, inclusive.	Excess of last four years over first four.	Excess of first four years over last four.
1	$265,310	$9,516,664	$9,251,354	. . . . .	14	. . . . .	$676,318	$676,318	. . . . .
2	41,400	1,421,140	1,379,740	. . . . .	15	$266,263	1,896,630	1,630,367	. . . . .
3	1,093,460	2,435,260	1,341,800	. . . . .	16	1,210,800	1,445,862	235,062	. . . . .
4	124,050	234,250	110,200	. . . . .	17	340,650	1,525,073	684,423	. . . . .
5	243,250	2,262,100	2,018,850	. . . . .	18	1,952,850	4,817,702	2,864,852	. . . . .
6	9,900	1,002,410	992,510	. . . . .	19	10,291,365	53,245,643	42,954,278	. . . . .
8	468,242	1,586,618	1,118,376	. . . . .	20	1,751,750	2,008,770	257,020	. . . . .
9	737,100	1,124,123	387,023	. . . . .	21	1,892,100	5,267,130	3,375,030	. . . . .
10	335,700	247,704	. . . . .	$87,996	22	3,666,075	10,983,910	7,317,835	. . . . .
12	175,175	1,783,374	31,608,199	. . . . .	Totals, .	$25,365,440	$133,480,681	$108,203,237	$87,996



Cut No. 41.—It thus appears that in only one of the wards traversed by the elevated roads, the tenth, did the increase in the assessments on real estate during the four years subsequent to the opening of the elevated railroads fall behind the increase during the four years previous; this is unexplainable except it be that the report is an error.

ruined;' one gentleman going so far as to say in his testimony that 'utter desolation had been brought about.'"

"Everybody who knows anything of the history of elevated roads in New York knows exactly the contrary to be the case. I had supposed it was well known that business had improved, real estate had advanced in value, rentals increased and cheerfully paid, increase of business warranting better rates along the lines of the elevated roads. To such persons as have not looked into the subject, I assert it to be the fact that real estate has so advanced in value and business has so increased. To offset this line of testimony I presented a letter, now on file with the committee, written by some New York gentlemen whose names will immediately commend themselves to the attention and judgment of the people of Boston, and especially to merchants and business men, to whom they will need no introduction."

"New York, January 18, 1884.

"Capt. Joe V. Meigs:—

"*Dear Sir*, — In reference to the inquiries you are making as to the working of an elevated railroad, and the effects produced on the trade of the districts through which they passed, let us say that we have no doubt that the general opinion of the merchants along the line of the Sixth Avenue elevated railroad will be confirmatory of the beneficial effects resulting from its introduction. There is no section of the city which has so grown in importance during the last ten years as the Sixth Avenue, and we have no doubt it would be an easy matter for you to procure the signatures of the merchants in that great business thoroughfare to the effect that their success is largely owing to the introduction of the elevated railroad.

"That the real estate all along the various lines has largely in-

creased in value is beyond all question, as you can easily ascertain from any property-owner in the city. Should you wish any further proof of the convenience and, we might say, absolute necessity of the elevated railroad to the welfare of this great city, we would refer you to the statement made by the companies that, during the year 1883, 92,000,000 people were carried by them in comfort and safety.

Yours very truly,

ISELIN, NEESER & CO.

"We fully indorse the above.

STERN BROTHERS, West Twenty-third Street.
H. O'NEILL & CO., 321 to 329 Sixth Avenue.
R. H. MACY & CO., Fourteenth Street and Sixth Avenue.
SIMPSON, CRAWFORD & SIMPSON, 307 to 317 Sixth Avenue, 101 to 109 Nineteenth Street.

Respectfully,

JOE V. MEIGS,
89 Court Street."

POPULAR PRICES MAKE TRAVEL.

"By a recent statement of the New York elevated railway officials the number of passengers carried by New York elevated roads during the year ending September 30, 1886, without injury to a single passenger *who sat in his seat*, were 115,109,591.

"Passengers carried for the first seven days in October, 1885, at ten cents each, 1,999,460.

"Passengers carried for the first seven days in October, 1886, at five cents each, 2,819,249.

"A gain of 819,789 passengers over those carried for the corresponding days of last year.

"An average of 315,369 a day for the year.

"And an average increase in money, at five-cent rates per day over the ten-cent rate, of $3,489.18.

"On one day, June 5, 1886, a day of strike, 557,114 passengers were carried."

A thinking person will at once see how vital the elevated roads are to New York City. They are no less necessary in Boston. With popular prices of fare, I believe as many passengers will be carried in Boston with the same number of miles of railway as in New York. On account of the shape of Boston, there is a necessity of concentrating business and spreading living-places. This will make riders and increase values everywhere.

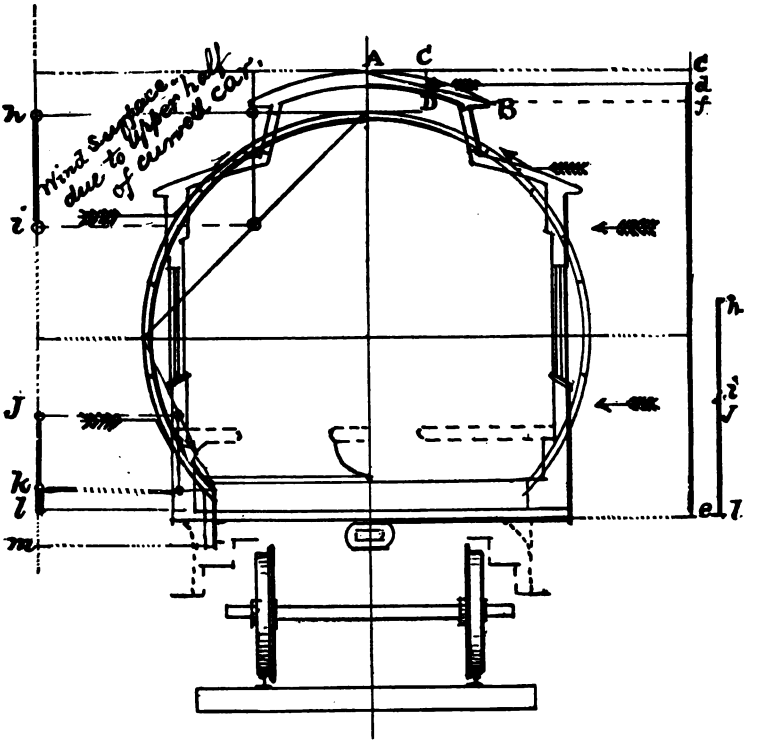
Now having shown my way, its strength, and the reasons for its adoption, the next thing in the order of my story and examination will be a shape of car which will give the greatest safety to the passenger, the greatest number of seatings, the least weight to be hauled per passenger, the greatest strength to resist accident and ability to resist fire, and to place the least strain on the way during heavy side-winds.

THE PART THE WIND PLAYS IN RAILROADING.

I have prepared a cut superimposing a cylindrical car body over a standard car body of the ordinary kind.

The force of the wind against the wall of the side of the car body is equal to the number of pounds per square foot multiplied by the aggregate square feet of the wall: its length multiplied by its height; but if we were to make the top of that car rounded, then, to find the strain due to that surface, we must draw a line from the highest point of the rounded surface of the car at A to its junction with the vertical wall B (erect a perpendicular, D C, to this, the chord line of the arc of the roof, at its centre) as high as the highest

point of the curve; then this height, multiplied by the length of the surface, would represent the number of square feet, which, multiplied by the force of the wind, would represent the wind-strain due to the curved surface A B. Now, as the force of the wind against the side of the car is one of the great elements of cost in railroading, it becomes very important to reduce the wind-pressure if we can do so without expense and without reducing the carrying capacity of



Cut No. 42.—Wind-surfaces of cylindrical cars and of ordinary surface railway cars compared and represented by the block lines on the right of the cut, *d e* representing the height of the wind-surface of the ordinary surface railway car, and *l h* that due to the cylindrical wall.

the car. Therefore I represent in the above sketch THE COMPARATIVE RESULTS OF THE WIND-PRESSURES of the two forms of car.

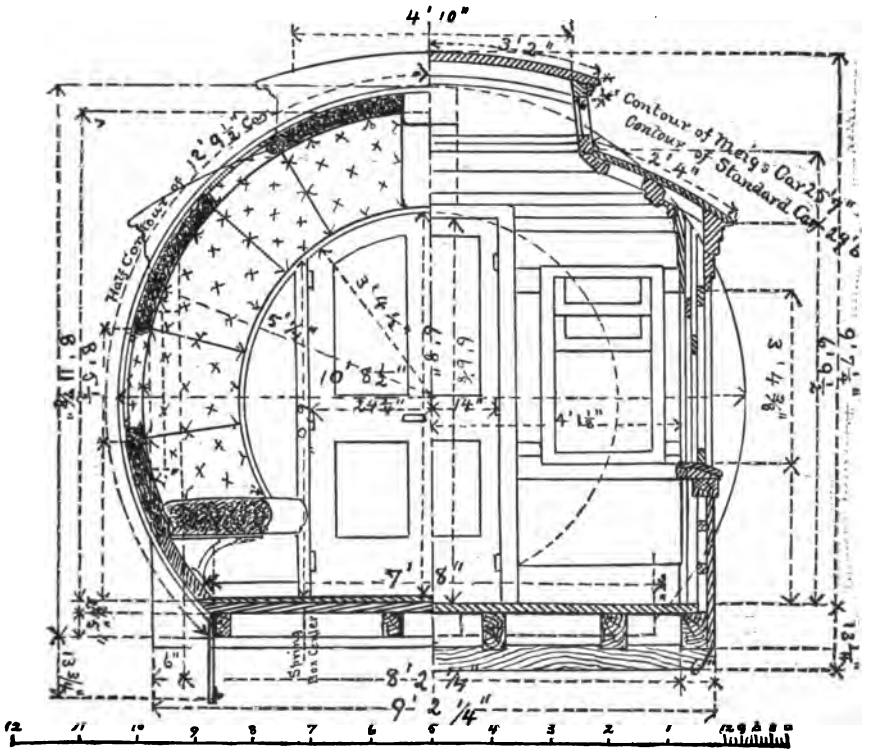
THE WIND-SURFACES FOUND.

The block lines of the cut represent the wind-surfaces of the two forms of car: *e-f-d* that due to the flat-sided car; *i-h* and *j-k* that due to the curvature of the cylindrical car, and *k-l* that due to the open bracework on the side of that car. These added together, as shown on the right of the cut, make a line about one half of *e-f-d*, and, as the lengths of the cars are assumed to be the same, a little, however, by reason of its rounded ends, in favor of the cylindrical car, the wind-pressures for it are but one half that of the flat or wall-sided car; this also includes for the round car the truck surfaces upon careful estimate.

The seatings are shown by the side-seats and the middle row: on the left-hand side for the cylindrical car and on the right for the ordinary; thus the cylindrical gains thirty-three per cent. more seats. Our model car, built for the test of the Commissioners, has been finished to meet every exacting requirement of carbuilder and railroad investor.

Imposing a cylindrical car body over an ordinary car body, making them of the same practical height, it is found, if you take a tape and follow the outline of the exterior of the ordinary car, commencing at the lower corner and following the contour of its exterior around its cornices and over the top, that a cylindrical car of the same height of the standard car will measure 47 inches less in contour, while it will contain a greater area. If, at the same time, we measure

the wind-surfaces, as we have just seen how to do, for the upper and lower portions of the curvature, you will find that the wind-strains have been halved, and that alone without any other reason — such as the reduction of weight and the gaining of greater strength by this method of construction, even though the car body were flattened at sides in an oval manner, where passage of trains requires it — proves conclusively that EVERYTHING IS IN FAVOR OF THE CYLINDRICAL FORM.



Cut No. 43. — Cross-section of standard surface railway car with Meigs cylindrical car superimposed, together with dimensions.

The purpose of making the housings of engine, tender, and car cylindrical is therefore because that form gives the least wind-strain and requires the least covering-material, affording a greater seating-space in the case of the passenger-car, as we have seen, and greater internal area in case of other cars.

The cars have rounded ends to move through the air easier, and because that form will push a falling person back upon, not from, the platforms.

I have covered them with copper, because copper oxydized black or brown lasts without paint or repair and grows better-looking with age. Copper, soldered well together, is air, dust, and water tight and will not burn.

Their frames are of iron, because stronger, and will not burn.

Their platforms are braced by side-girders and are continuations of the floor, because that is the strongest form to resist telescoping.

The floors are double and iron-lined, because if a stove were to spill its fire on the floor the fire could not spread into a conflagration, and are very much stronger.

The gates slide up and down, are out of the way, and do not catch ladies' dresses.

The walls are covered outside with panels, covered with copper, laid on paper, which in turn is laid on iron closely nailed to the wood of the panels, so that they are very strong and are fireproof. They are fire-proof upholstered inside, because more elegant and durable, and if one is thrown against them they do not cut or bruise.

Each of the seats in the separate row in the middle of the

car is fastened down so as to be instantly removed if desired, is of malleable iron, is capable of being turned up out of the way, has no legs which occupy the space for foot or bundle, and yet has foot-rests and is upholstered at all salient points, so that, in case of collision, passengers are not to be cut by the seats, nor will the seats be detached and fly about like missiles.

The doors are double, permitting easy ingress and egress.

The roofs of platforms will interlock and cover the space between cars, keeping out weather and dust.

The windows may be opened outward from either side in opposite direction to movement of train, and admit plenty of fresh air, without draft, in all weather, and are so housed as to let in no dust.

Ventilation is secured by an outsuck, from top and floor of car, occasioned by movement of train.

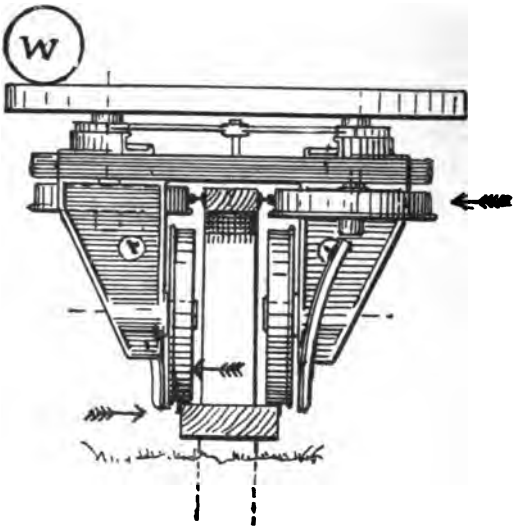
MY WHEELS EVOLVED.

Now, having examined the way and form of car to go upon the way, and the shape of the truck-frame astride of the track, we will go into the question of putting wheels upon that frame. See cut No. 15, p. 39. If we were to put horizontal wheels upon it, to meet wind and side thrusts, those wheels might be made with ordinary flanges, and by running the flanges under the upper rail, but far enough away from the rail not to touch, unless called into play by some great strain, we would lock the train to the track.

VERTICAL WHEELS SHOWN.

By placing vertical wheels under the trucks, with similar flanged wheels, we would have a truck like that which this

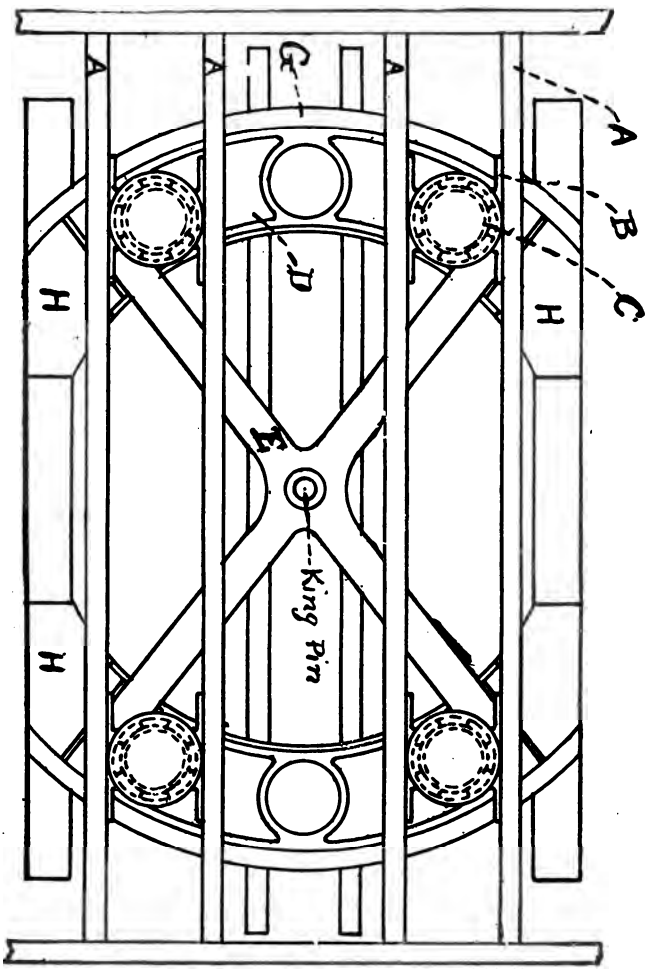
cut represents, and which I have patented. By inspecting the cut and noting the resultants of the strains it will be seen that the lower or supporting flanged wheels act exactly as all flanged wheels will do under similar circumstances of unbalanced load: rub and strain the wheels, and pass over the switches and tracks with great friction and



Cut No. 44.— One of the forms of the Meigs truck patented but not proposed to be used, illustrative of the absurdity of the use of vertical wheels upon such trucks. Flange frictions and twisting strains not corrected thereby. These are corrected by the angular wheels. The arrows show forces and resultant strains.

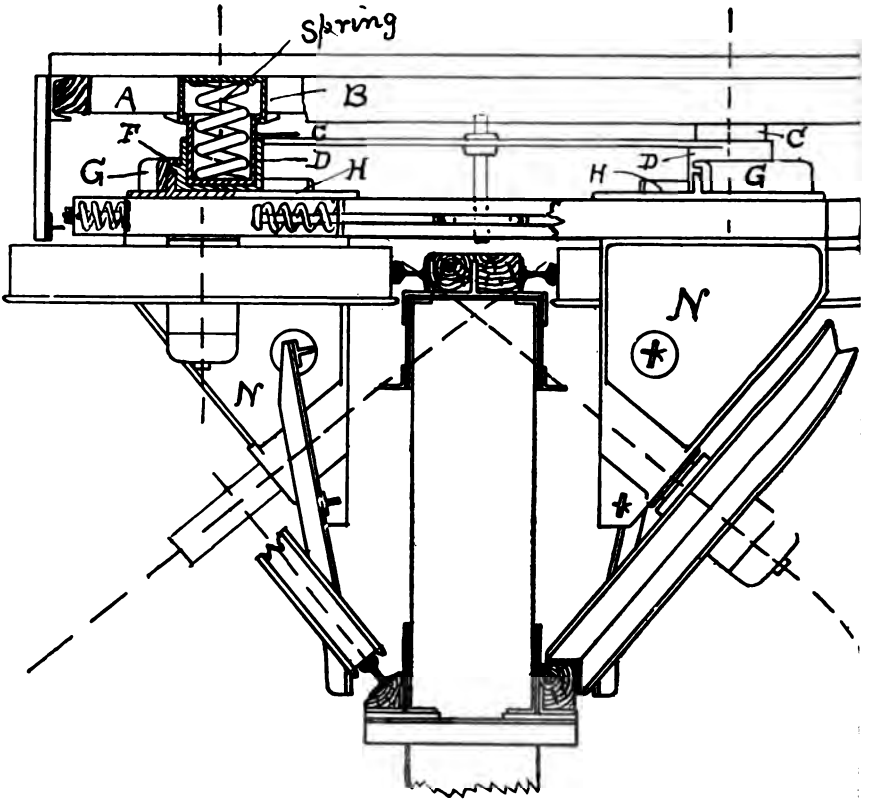
strain. Therefore it behooves us to place such wheels upon the trucks as will rid us of these difficulties, and to attach the trucks to the car body in a manner very much stronger than has heretofore been done. To support such wheels, and attach them to the car floor, I have placed cross-beams, A, A, A, A, reaching from side to side to strong longitudinal

girders which form the outside floor-beams of the cab or car, and making a telescope-resisting floor thousands of



Cut No. 45 — Plan of Meigs truck, showing the general method of construction. H, top of truck. A A A A floor beams of car. D, slide, or turn-tables, connected by cross-brace E. G, holding-down lip. C, one of four sockets for telescoping posts, carrying springs, and attaching car to truck.

times stronger than those commonly in use; between these cross-girders, boxes, B, have been placed; telescoping into



Cut No. 46.—Meigs truck, showing the general method of construction. On the left-hand side a portion of a double-flanged wheel is used to show the utter absurdity of such a wheel.

N, jaws attached to platform of truck to carry axle. G, lip fastening turn-table to top of truck. B and C, spring boxes. — — — dotted lines through axles, shown as radial lines leading from the upper rails, about which, side thrusts must turn trucks, thrusting engendered force down centre lines of wheels.

these are other boxes, C. These are held in a sliding-frame, D, D, and are connected by a crosspiece, E, making a sort of turn-table, the outer lip of which, F, is held down by a piece, G, attached to the top-plate, H (see cut 46, p. 102), which is firmly fastened to the top of the truck-frame, the kingbolt serving merely as a pin to which the drawbars are attached. Upon inspection of the cuts it will be seen that the springs which deaden the shock between the trucks and the frame are placed in these telescoping posts. In the plan-view the horizontal wheels are left out, because it is the purpose of the cut merely to show the top part of the truck-frame and the points of attachment of the car body. The horizontal wheels, however, as shown in the elevation, are pendant from sliding-boxes and held against the upper rail by springs pushing against the boxes, and housed in by resistant ends attached to the middle cross-girders; these springs take up all side-shock, eliminating lateral motion, allowing high speeds to be got with little or no shock when the abrupt changes from straight line to curves are made.

This form of attachment is *a thousand times* as strong as that now in use upon the common railroads.

The bolts and nuts have been purposely left out in the drawings, because they would unnecessarily complicate them.

CAR FLOOR AND TRUCK.

But perhaps it would be best to describe this attachment of car floor and truck in general language, without reference to letters indicating the parts, and compare it at the same time with the ordinary surface and elevated railway trucks, using a 4 ft. 8½ in. gauge.

The attachment of the trucks to the car bottom is accomplished by four sliding-posts sliding in sockets secured in the car floor. These hollow posts, two on a side, are let into a casting and then are attached to each other by a crosspiece between the posts; those parts connected by the cross-frame and holding the sliding-posts are broadened out, flattened on the bottom, curved at the outer edges, and there lipped, rotating around a centre at the kingpin, and sliding in a broad channel, sliding as they revolve under a holding-down lip, attached to the wheel-bearing part of the truck, so that the kingpin does not serve to fasten the car to the truck, but only for attachment of the drawbar, and is located at the centre of the cross-framing; otherwise said, the parts attached to the car bottom make a sort of turn-table revolving or sliding in a wide channel upon the top of the truck and held down by a flange which is securely bolted to the top of the truck.

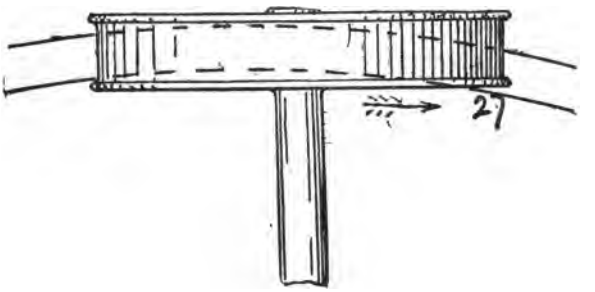
FASTENING OF CAR TO TRUCK STRONGER.

The flange on the outer edge of the turn-table is at the right point to resist the strains of rupture between the truck and car bottom, without introducing leverage, which is not the case with the kingpin attachment of the standard car used on ordinary railways, as seen in cut No. 18, p. 55, and rendering the new attachment, it is safe to say, a thousand times as strong as the old.

WHY WHEELS RUNNING LOW ARE USED.

To make plain why my supporting-wheels run on the lower boom: It lowers the centre of gravity and makes derailment impossible, straddling the truck-frames and

wheels over the way for forty-eight inches. If supporting-wheels had been placed to run upon the tops of the way, and vertical wheels had been placed on the lower boom, I would have had but two supporting-wheels, an insufficient number for large cars, or else a clumsy truck to bear a greater number, all of these wheels protruding into the car, if the centre of gravity is noted by the constructor, and



Cut No. 47. — A double-flanged wheel shown in connection with a curve. Showing the tendency to derailment introduced by crisscrossing the wheels and way.

limiting the capability of turning curves. These things would be elements of weakness.

A double-flanged wheel would have been required, and this would lead to serious causes of derailment whenever a change of direction should be attempted, because of the crisscross nature of such wheels, as seen above, unless the flanges were very deep, which would make vast frictions and corresponding costs and add to the danger of breakage; the car bottoms being necessarily high would, at moment of wheel-breakage, give plunge to them; therefore I did not consider such wheels admissible at all, although I built models and took patents upon them.

There are but two things remaining now to complete this cursory review, to wit: The wheels which we shall use, their principle of application, and the method by which we utilize the steam with which to draw the trains.

A RIGHT-ANGLED GROOVE-FACED WHEEL HAS BEEN USED because it has no flange friction.

Before we can understand fully the benefit of inclined wheels such as I have introduced, it will be necessary to follow carefully the series of sketches following, so as to rid one's mind of the fact that we are not discussing the boy's

LOOSE WAGON-WHEEL

and its underlying data, which make the ill-fated wheel wabble about upon its axle and scour the sides of the wagon, pinching and wearing the axle and scoring itself with the retaining-pin. These things do not occur at all with such wheels as I use, even though the axle be entirely too small to fit the hub-hole.

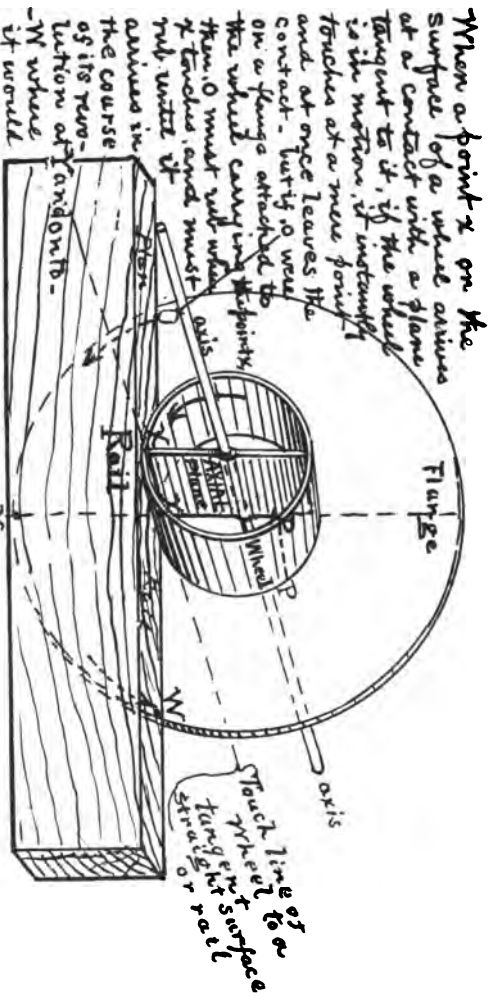
FLANGE AND ROLLING FRICTIONS.

To show the ordinary wheel and its flange in an exaggerated manner, as well as to show it correctly, two cuts have been made: one represents the ordinary flange in full size (see cut No. 14, p. 37); cut No. 48 shows a hollow wheel, flanged, and resting upon a plain rail of wood.

The wheel is attached to a large flange, which rubs against the back face of the rail. I have drawn an axial plane within the wheel, so that it does not require much of an imagination to observe that this plane extended through the

thin rim touches the plane surface of the rail at its point of tangency by a mere touch-line.

The wheel recedes from the contact-line in both directions, and shows that if the wheel is rotated first in the direction


When a point x on the surface of a wheel arrives at a contact with a plane tangent to it, if the wheel is in motion, it instantly touches at a mere point and at once leaves the contact - but if a weight is attached to the wheel carrying the point x then x must roll until it arrives in the course of its revolution at Y - where it would be free once more to travel in space, like x which does so from moment of contact, therefore flange friction should be avoided as much as possible,
Flange
Wheel
Axle
Axis
Rail
Plan
Touch line of wheel to a tangent surface or rail
Straight
axis

Cut No. 48.—Showing a hollow wheel provided with wide, thin flange, showing the axial plane and tangent contact. Used in illustrating the difference between flange and rolling frictions, and to show the want of correct principle in the ordinary surface railroad wheels.

of the arrow and then in a contrary direction, every observer must note that the touch-point of the wheel and the axial plane must be on and off instantaneously and that the rolling-surface of the wheel does not drag; but if at the left-hand side of the wheel the dot at O upon the flange is noted, it will be seen that when the face of the wheel at X–X, being put in motion, arrives at its tangency, the dot will begin to rub in the direction of the dotted arrow from O to Y to W; and while the tangent-face, X–X, of the wheel, which arrives at contact with its tangent-rail at the same instant the dot O arrives at contact, will move in space a distance equivalent to X–P, while the dot drags from O to Y to W.

This momentary contact of the wheel is rolling friction; and this dragging contact of the dot and ever-recurring face, comprised by O, W, Y, O, is the grinding friction of all flanges; mere beveling of the flange intensifies the friction but does not reduce it; and the reader does not need to be told that, if we could get rid of it, it ought to be done. Safety, economy, cost of fares, living pay of the employees, and honest dividends all require it.

FLANGE FRICTIONS.

In the practice of modern railroading, the flange friction is that due to an inch-flange; this height being found to be the best, considering all things, the frictions due to this flange are varied more or less by the diameter of the wheel. The ever-recurring contact-point of a flange an inch high of a 42-inch wheel drags 13 inches.

I have therefore used a right-angled groove-faced wheel, which has no flanges at all, and in the use of which there are no flange or dragging frictions whatever.

RIGHT-ANGLED GROOVE-FACED WHEELS PROVED TO HAVE ROLLING CONTACT.

This has been so strenuously denied, and the denial supported by argument based upon false *a priori* conditions, that I propose to devote a little more time to the proof of the correctness of my practice at East Cambridge than I otherwise would.

THE PRACTICE OF RIGHT-ANGLED GROOVE-FACED WHEELS.

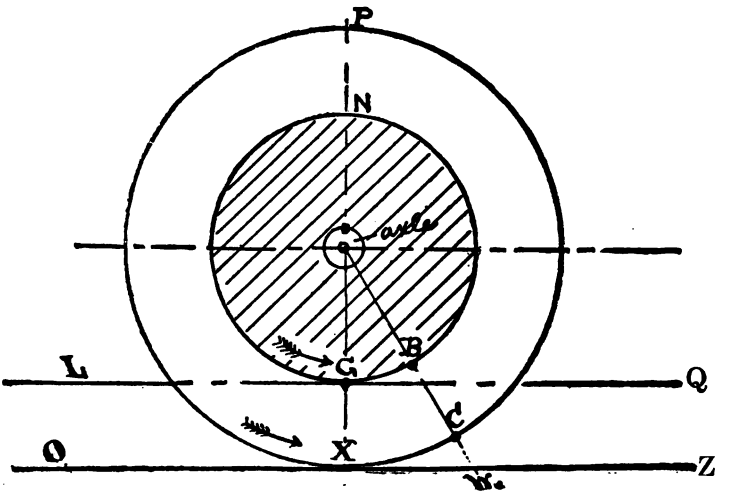
First of all, let me state that when a piece of paper as thin as tissue, or as fragile as a wet newspaper, is laid upon the rail at East Cambridge and run over by such wheels as support my engine and train, no matter how heavily laden, the wheels merely roll over it without grinding it up, as it would if there were flange or dragging frictions.

Surely this statement ought to be proof enough; but as it can be shown here upon these pages to those who have not seen it, let us do so.

THE EVOLUTION OF THE RIGHT-ANGLED GROOVE-FACED WHEEL.

The cut shows two thin wheels fastened or keyed to the same axle so as to revolve in the same time. Now, the smaller or shaded one arrives at tangency G to its rail L, Q, at the very same instant that the larger one arrives at its tangency X to the rail O, Z. Arriving at tangency each a the same instant, they leave tangency or touch upon revolution at the very same instant, leaving touch together, and hence travel in space together.

It is true X travels a greater distance than G, but the travel is in space and in the same time, and is not grinding as in the case of a flange. Now separate the wheels, slip them apart along their common axle so that they may be parallel to each other, but separated, — the rail line O, Z, in a separate plane from L, Q, — this does not change the facts of touch and tangency as stated.

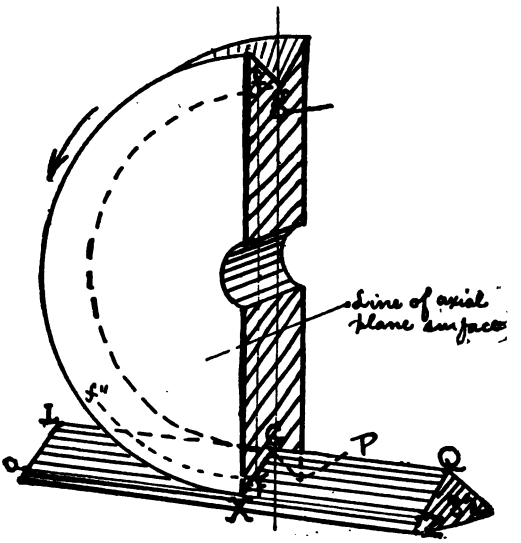


Cut No. 49.— Disks placed upon an axle to be used in illustrating the evolution of a wheel with right-angle grooved face.

But suppose we connect these separated planes by plate wheels infinitesimally thick — each parallel to the other, each of them infinitesimally smaller in diameter than its next plate, and tangent like the others to a plane track or touch-lines, and parallel to O, X, Z and L, G, Q, then each of them, like the outer and bounding disks, G, B, N, G and X, C, P, X, will roll, as to tangency, exactly as they do each upon its own tangent surface. No one of them could drag,

because they all become tangent to their supporting-planes, revolving about the same centre at the same instant, and at the same instant each leaves its contact-point.

It being admitted that all cylinders, *no matter of what diameter*, when brought in contact with a plane surface meet that



GROOVE-FACED WHEEL.

Cut No. 50.—The half of one of my right-angled groove-faced wheels cut at its axial plane and shaded by hatch lines, showing the line or tangency touch of the face of the wheel with the rail, and a total absence of any flange friction whatever. Rotate the wheel in the direction of the arrow and every point in contact will at the same moment leave contact. The half-circles $X f$ and $G g$ are of different diameters, it is true, but they are at contact or tangency only to the supporting surface, or rail.

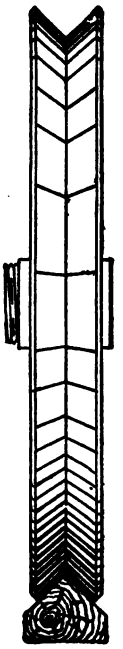
surface at a mere touch-line; then *the points* of tangency of each of the infinitesimal parallel layers or plates of matter which comprise and go to make up the cylinder would be in a line, and connected thus, become the face-line of half of a wheel like mine.

These layers of infinitesimal planes, when so added one to the other, build up a right-angled groove-faced wheel, as here sketched, but cut in half by an axial plane, showing the tangency of its periphery to be but a mere touch-point, like the tangency of any circular body with a plane surface. You can prove it without doubt by simply imagining the rotation of this wheel about its axis upon its rail in the direction of the arrow, when it will be seen that the line X, F, G, P, its face or touch-line, must at once, instantly, be lifted into space by its rotation, or, in other words, the touch of tangency instantly removed; it could not be otherwise, the theories of the "rolling-cone," the "wabbling-wheel" fellows, and all others to the contrary notwithstanding. But still further, to show the recedence of the surfaces of contact, and to show that they are mere tangencies at touch exactly similar to ordinary wheels, I place them shaded side by side, and it can be seen by the eye of the poorest observer that the contact of cut No. 51 is mere tangency; and more, that the right-angled grooved wheel has no flange, but that any increased pressure would be merely in kind, rolling friction, and not flange friction as would be the case with the ordinary wheel (cut No. 52), were shifting pressures brought to bear.

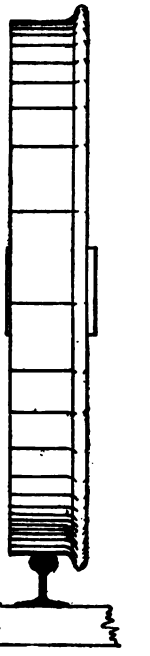
THE RIGHT-ANGLED GROOVED WHEEL APPLIED TO THE TRUCK.

Now, having decided that with such a wheel there are no flange frictions and having proved it by reasoning, by practice, and with model, we will try to apply this wheel to a way and to a truck-frame so as to secure a right-angle support of

the load by the wheel under every possible condition of use. If I had not foreseen that wheels could be so applied to the post-supported way which I had adopted and built in advance of my engine, it never would have been possible for the engine, with its 12-inch cylinders drawing seventy tons, to ascend the grade and tortuous tracks which you have seen done at East Cambridge. And it was this con-

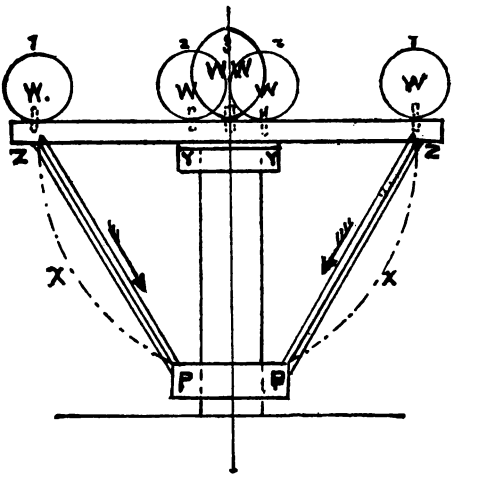


Cut No. 51 shows a right-angled grooved wheel resting upon a tangent piece of track suited to its face. By looking under it, it will be seen that its faces are in mere touch or tangency contact to the support, the same exactly as in cut No. 52, and shows that if it were shifted to left or right it would merely increase the force of contact.



Cut No. 52 shows an ordinary surface railway wheel resting upon a rail suited to it. It shows the mere touch or tangency contact to the support, the same exactly as in cut No. 51; but also shows that were it shifted to the left the face of the flange would make a rubbing contact were it put in motion.

fidence, substantiated by reason and fact, which enabled me, in the long run, to prove that I was right, and that the then railroad commissioner of another State knew what he was talking about when he said that "I was either a fool or knew well what I was about, when I built such a track, in such a manner, in such a devilish place, where, if a straight line could be built successfully, it would be a complete demonstration of the whole problem."

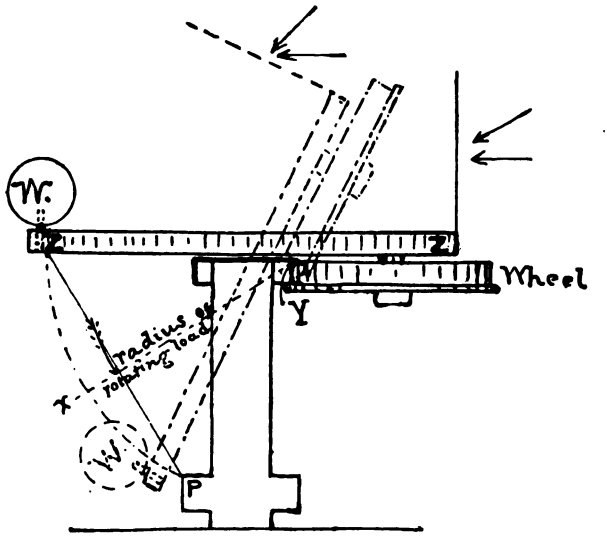


Cut No. 53. — Illustration showing the support of balanced loads by props. The points of resistance P, and the length of platform support *z z*, being given. First step in arriving at the reasons for placing wheels at a seeming angle.

But let us evolve the straddling trucks and inclined wheel as we have the wheel itself.

Suppose we take a platform and put it across the top of a vertical track, and support it by sticks or props P–Z, and P–Z resting against the lower part of the way P, P, and place balancing loads 1 W and 1 W upon the extreme ends of the platform, then the strains produced by the loads would be thrusts down the centres of the sticks as indicated by the arrows; but if I move the loads inwards so as to occupy the positions 2 W, 2 W, then the loads would be pressing down the centre lines of the sticks as before; but sup-

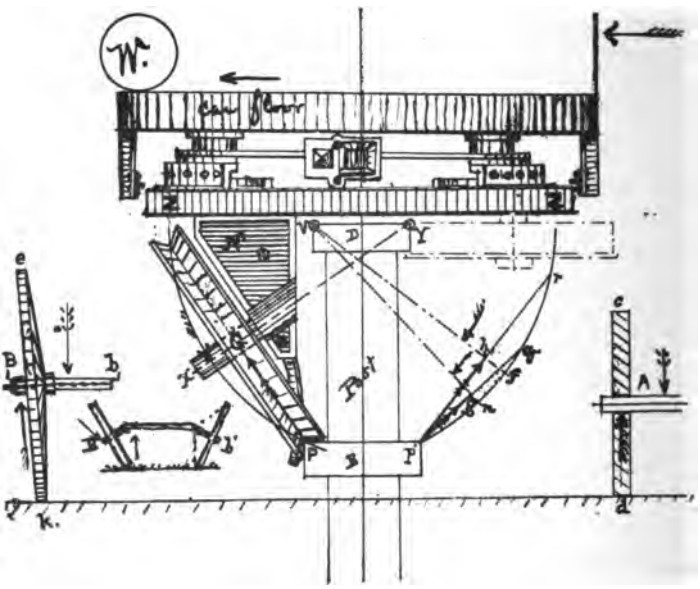
pose I merge the loads so as to occupy the exact central position of X–X, as shown by 3 W W, still I have made no change: the load presses down the props in the direction of the arrows; but suppose I change the conditions a little and place a wheel upon the under side of the platform Z, Z, and load the end of the platform with a weight fastened



Cut No. 54.—Second step in selecting a correct position for a supporting-wheel.

to it, then the platform, being unsupported at its end, will rotate around the contact surface of the wheel at Y with the upper corner of the girder or way, assuming the position shown by the dotted lines. The line of the rotation of the point Z, under the weight W, would be Z, *x*, P, and a prop to resist that load would be the chord Z, P, of the arch Z, *x*, P; if this twisting were produced by a wind as shown by the arrows, the result would be the same.

I now make the piece or platform Z, Z, the top of a truck-frame connecting it with the car bottom as we have seen heretofore on page 9 (cut No. 2); now if you will note the arc Z, *x*, P, on the left of the cut and its chord Z, G, P, you will see that if the weight, placed now upon the car floor, were to rotate the top of the truck-frame Z, Z, it would best be supported by a prop in the straight line F, G, P, the chord of arc Z, *x*, P.



Cut No. 55. — Illustrates the position of the angular wheels. The radiality of its axle X Y, which revolves about the upper corner Y when subjected to unbalanced loads. Showing the resistance of these wheels to be at right angles to the axle; also showing on the right-hand side, that the diameter of the wheel fixes its axle's angle (see pp. 18 and 39); the axles shown being the radial lines revolving around the upper corner of the way. See *Vn* and *Vf*, illustrating the position of wheel and axle for two different diameters; thus it is seen the diameter of the wheel fixes its angularity. The principle of right-angled resistance of the lower part of the wheels is well illustrated by the smaller sketches in other usages. My "angularly placed" wheels secure this result for both balanced and unbalanced loads.

Let us make one other step forward and connect a cheek-piece N to the under side of truck-frame or platform Z, Z; these cheek-pieces are very clearly seen in cut No. 15, p. 39; but now suppose the unbalanced load W were to rotate the car floor and with it the truck-frame Z, Z, around the point Y; then if an axle were put into the cheek N, and as seen more clearly in cut No. 15, it would transmit the pressure, of all loads and of the thrusts of wind, at right angles to the revolving wheel, its support; to do this the axle ought to be a radial line from Y, piercing the centre of the right-angled groove-faced wheel at right angles, the centre plane of which should be Z, G, P (cut No. 55), a chord of the arc Z, *x*, P; that arc exactly because it is the arc swept by the radial line X, Y, revolving around Y and passing through P, the point of resistance selected; this wheel would be the exact counterpart of our props Z, P (cut No. 53), and of our chord line Z, P (cut No. 54), and chord line Z, G, P (cut No. 55).

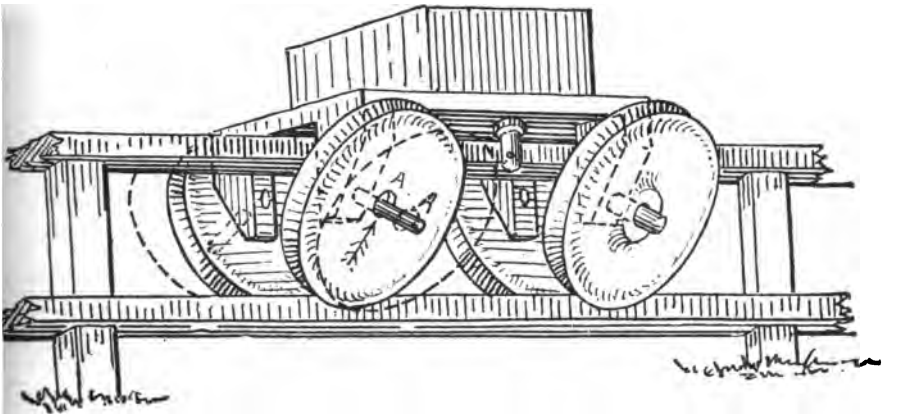
If a wheel of smaller diameter should be used, then that wheel must have its axle placed in a radial line *Vn*, or *Vf*, like axle N, as shown on the right hand of cut No. 55, p. 116; and it will not require much imagination on the part of the observer to see that every unbalanced load, whether produced by wind or any other cause, must rotate the axle about the point Y and must cause it to thrust directly down the chord of the arc of the rotation of the axle. That is, always by a right-angled thrust upon the load-resisting wheel; this is very clearly seen in cut No. 46, p. 102. On the left-hand side of this cut, a double-flanged wheel has been placed, but because of the friction produced by this wheel upon

the presentation of unbalanced loads, obvious to any sort of an observer, it would be nonsense to use it when we had altogether a better form of wheel. In cut No. 55, p. 116, are shown in small size the ordinary dished and straight bearing-wheels as commonly used, showing the direction of the resistances and application of the force by the arrows, and we need not go into a discussion of their principles, which are now self-evident; I have put them here for the convenience of those who may think about the subject.

The model which I built, and here illustrate, is more convincing of the true principle of these wheels, if it is possible, than either the practical application of the trucks as seen at East Cambridge, or that of our reasoning that the principle of our "inclined wheels" is correct. These wheels support balanced loads or unbalanced loads so that the pressures of the load are always transmitted through the axles at right angles to the bore of the wheels. The proof that the rotation of the load about the junction of the horizontal wheel and the upper track always causes the axle, which is set in the frame, to thrust upon the wheel at its bore, pressing at right angles upon the face of the bore in the hub, causing the wheel always to support the load at right angles, would be undeniable if we could build a model upon the principle and could put the right-angled groove-faced wheels upon axles entirely too small for the bores of the wheels, and then these wheels should run true and not wabble about. Then if they did run true the reasoning upon which this evolution is based could not be doubted.

THIS SKETCH OF THE MODEL

which I have in my possession shows exactly these conditions except that I have made the demonstrating wheel so thin at its bore that if you did not see it run true and resist being thrown out of true, returning to the normal position upwards or downwards, unlike the boy's wabbling cart-wheel which



Cut No. 56.—One of my illustrative models with thin hub running steadily on loose axle, proving that no wabbling about of the wheel, like ordinary loose wheels, occurs, and that the loads on such wheels are always received by the wheels at right angles to the axle (see arrow) and that the wheels remain stable while easily accommodating themselves to the passage of angles or other uneven track, and right themselves when thrown out of true, so that space can be left on each side of wheel, ridding us of all end frictions; and by fastening a cap on the wheel itself, which covers the protruding axle, it would make a sort of bucket of the axle-hole which might be filled with oil; this we do.

always runs untrue, one could not believe such a statement. I was so confident that thin wheels would behave as well as those thicker at their bores or bearing-faces of hub to axle that I took my penknife, in the presence of one of the committees of the Legislature, and cut away the hub so thin that the wheel had scarcely any bearing at its bore, being very thin, as shown in the sketch. The bore for the

axle as illustrated was made larger than the axle's diameter by one third, yet the wheel in that condition resists all attempts to make it run untrue, proving beyond doubt that the principle of its construction is correct, for it does not wabble or score like the boys' wagon-wheel, but runs steadily and true.

There is an additional proof even beyond all this, in the use of this model, to wit: That if the track should be widened, then the wheels ought to run true if the principle were correct, lifting up the load in running out to meet the widened track, still running true upon the axle.

If anything would throw the wheels out of line and make them wabble, this would, and yet they run true. How any person could in the face of the practice at East Cambridge deny the correctness of the theory upon which these wheels are laid is vastly more than I can conceive.

The examination of the axles at East Cambridge, which have been submitted to all sorts of uneven track and unbalanced loads, proves that they are based upon correct theory, for they have worn absolutely true and are in as good condition to-day as the day they were put in: notwithstanding that our experiments and efforts were directed to test them and break them if we could.

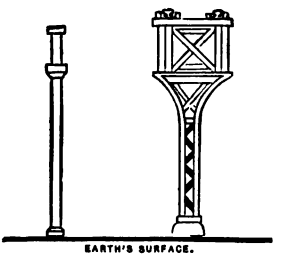
The sleeves, or oil-distributors, around the axles are perfectly worn in all parts. The bottom of the axles and their tops as tried with a straight edge were shown to General Stark to be as true as the day they were put in.

The right-angled grooved faces of the wheels are similarly worn true, although they are made of perfectly soft gun iron and have been tested in a very severe manner.

Idle criticism has been launched at the enterprise because of the breakage of some parts of the machinery when put to the tremendous tests to which they have been submitted — for the very purpose of breaking, if it were to be.

Because one can't catch a shark with a codfish hook it is not a proof that hooks are not good for anything, because it is perfectly possible to make a hook strong enough to hold a shark; and I have been experimenting, with the advice of my directory and associates who subscribed their money for the very purpose, to find out where the breaking-point lay, if I could, especially as I had shown and proved the capability of my engine to do the things which I had claimed, when we used but 12-inch cylinders.

The results of my experiments are eminently satisfactory to everybody who has examined this experimental railway, and to those who have placed their money with their confidence in me, because I have shown by the extended experiments which we have made at East Cambridge, involving the direct outlay of $100,000, that they were based upon careful estimates, the results of many years of labor, and prove incontestably: —



CUT NO. 57.

First, that a post-supported railway after my plan with trucks astride of the way is practical and safe and absolutely free from all of the accidents common to ordinary surface railways which cause the loss of life and limb, such as those occasioned by surface collisions, by obstructions,

by washouts, by storms, by broken rails, by broken axles, by broken wheels, by burning, and by broken engines; no one of such accidents can produce the death or even the maiming of a single person. We have proved this practically. We have tried most of these things under speed and slowly, and know that passengers can and have ridden upon the Meigs Railway under such conditions as would result from broken rail, broken axle, broken wheel, broken engine, obstructions, and surface collision, without the slightest danger and without being aware of the fact when it had occurred. A committee of the Legislature was ridden over a railless track, and they never discovered it or thought it worth mention when attention was called to the fact, though if it had been on an ordinary railway many of them might have been killed.

Second, that the locomotive of the Meigs Railway, securing its adhesion by mechanical means, enables the engineman to grip the track with whatever power he may require, to utilize successfully the whole effective tractive power of the largest cylinder that might be required to do any kind of duty, such as speeding, climbing grades, or pulling heavy-laden trains.

Third, that there is no limit to the size of the cylinder which could be used with this system because we have proved that our tracks, trucks, and car floors are strong enough to carry upon them, if we chose, packed like sardines, the heaviest guns made by the South Boston Iron Works, and there is room enough upon the engine floor, because we do so, to place a boiler which would make steam for any diameter of cylinder which either speed, grade, or pull could require.

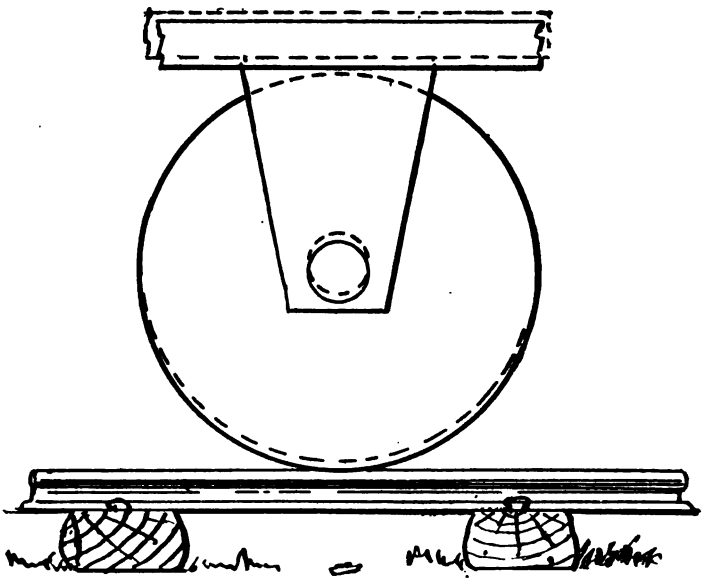
Fourth, that this form of railway will secure safety at any speed which may be desired, and any speed which may be desired can be attained.

Its safety and strength have been officially approved after nearly three months' examination by the able and experienced engineer General George Stark, whose experience could hardly be matched, for he was a young engineer in 1837–38 on the Lowell and Nashua Railway; built this end of the Old Colony; engineer of the Boston, Concord, and Montreal; of the Concord railway; and of many others; general manager of the Boston and Lowell for eighteen years; four years vice-president of the Northern Pacific; all his life spent in railroading: and hence it is that I am very proud of his decision and approval; and because of his capability to judge, although I did not know him, was glad of the appointment of so able an examiner by the Railroad Commissioners, to make an official examination, as required by the charter.

LARGE WHEEL-BEARING SURFACES EXPLAINED.

There is but one other question in relation to the wheels which is a departure, and that is the large bearing-surface of the faces of the wheels; this has been adopted because it serves to prevent such wear and tear as is brought upon the limited surface of the ordinary wheel, enabling us to make the faces of the wheels comparatively soft instead of hard, so that the wheels may be turned up true, ridding the trains of the difficulty which is exhibited in the cut on p. 124. This cut shows by the dotted lines an ordinary wheel which is out of true. This is often the case with very hard-surfaced

wheels, it being impossible to turn or grind them true without changing the texture of their faces; these

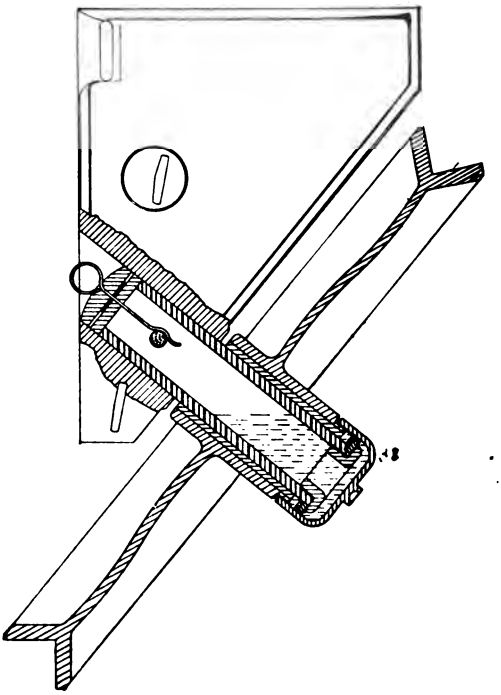


Cut No. 58 shows by the dotted lines the effect of a wheel out of true upon a car floor. This is a very common annoyance. It also shows the unstable and broken support of the rail by cross-ties. This is the kind of place in ordinary tracks at which a primary accident, to wit, breakage of rail, does not remain primary but causes smashing and holocausts.

in every revolution pull the car floor up and down by the amount of their eccentricity, to which must be added the increased reactive effect of the springs.

To fasten the right-angled groove-faced wheels on their axles and oil them thoroughly, a part of the axle is flattened off, and upon that is placed what is known as a dead-washer, one that cannot turn; placed next that is a live-washer,

or one that has no flattened surface and revolves; in the end of the axle, which is made hollow, and tapped out, a hollow screw, which has a head large enough to hold the dead-washer on, is inserted; thus fastened, the wheel which is on the axle cannot get off by its own revolutions, neither can it nor will it bring to bear a force upon the screw which will unlodge it. All of this is clearly seen by the sketch. An outer cap or hub is screwed on to the wheel against a wire gasket, thus making a sort of bucket of the axle-hole. The axle and



Cut No. 59 shows the method of oiling my new wheels. They thus run in a bath of oil; no hot-boxes. Turn the wheel up horizontally to see method of oiling wheels so placed.

retaining-nut being hollow, the radial axle is inclined for the inclined wheels; and standing vertically for the horizontal wheels, when the caps are fastened on, they may be filled with oil; around the axle is a sleeve or distributor upon which the wheel runs, and thus the wheels run in a bath of oil,

FOREVER ABOLISHING HOT-BOXES,

reducing the resistance and lessening the power required. The simple expedient of fastening a revolving piece so that it will not unscrew, no matter how run, is used in all ordinary gas-cocks.

It remains now for us to pay a little attention to the reasons why the form of motor used has been adopted.

THE ENGINE

is an anthracite burner because it makes a hot fire, without smoke, and, as I use it without contracting the exhaust, is without cinder. It is slotted yoke connected because the breakage of the crank-connections is harmless to the enginemen, passengers, and machinery. Its boiler has a fire-box, 54½ x 54 x 55 inches, because bottom is wanted in a teakettle to evaporate .water. It has a 5-foot shell, having 208 2-inch tubes, 84 inches long, because it is of size to contain water from which to draw steam — and steam is what is wanted to pull loads. Small, light boilers boil water and steam both and are not as economical or effective as those with plenty of water. Our boiler was made by Russell & Sons, of South Boston, of the best Benzon ⅜-inch steel, to stand a working-pressure of 150 pounds per square inch.

The engine when first built had two cylinders 12 x 22

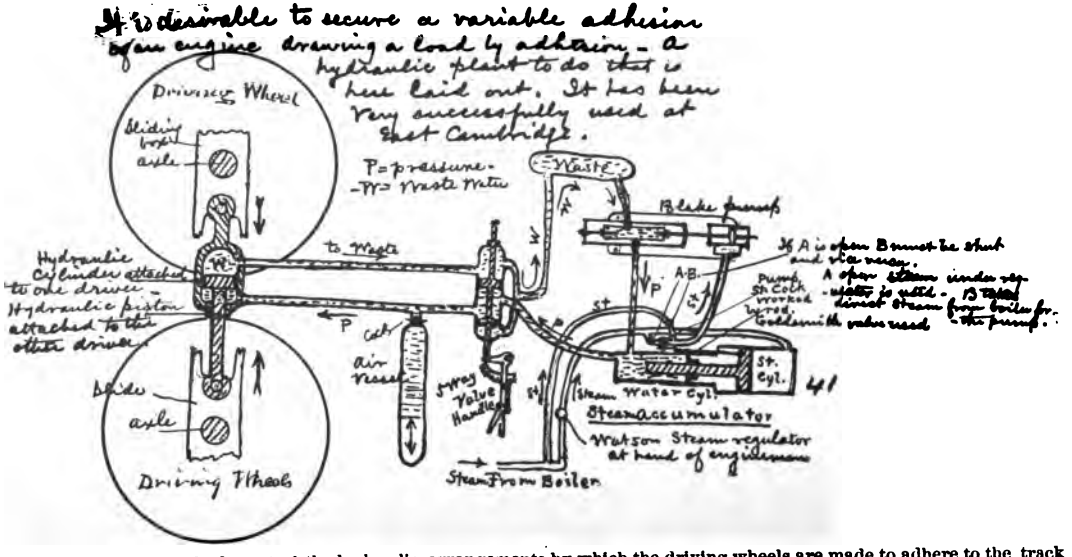
inches which have been replaced by others 16 x 22 in. coupled to two 45-inch diametered 6½-inch face driving-wheels, applied to secure adhesion by controllable hydraulic squeeze to 3½-inch faced rails — thus adhesion is limited only by the strength of the parts of the machine. This squeeze can be used for brake-power, and thus the engineman who may reverse his engine has complete control over his train without dragging his wheels.

The exhaust is without contraction, and for this reason is less noisy than exhausts for engines of similar dimensions doing approximate duties, and it produces no back-pressure. By peculiar arrangement of stack a perfect exhaust is secured without choking.

The ordinary link valve motion is used.

The experimental engine weighs thirty tons, and is rather heavier than another engine with same diametral cylinders need be. It is covered with a cylindrical cab, which serves to keep heat in and bad weather out. It looks like the tender and car, except that the engineman commands the train, its motive-power, couplings, and brakes, from a pilot-house high up at the front of the engine, governing every part of the engine by hydraulic power, through the instrumentality of valve levers, arranged upon a table in front of him. He is in easy communication with the firemen at the rear end of the engine.

The tender of the engine carries two cylindrical water-tanks, capable of holding 1,800 gallons of water because they were found to be stronger, and weigh less, and carry more water for the same weight of tanks than if of other form. It has room for ample coalbins, and is suitable for baggage as well.


It is desirable to secure a variable adhesion of an engine drawing a load by adhesion - a hydraulic plant to do that is here laid out. It has been very successfully used at East Cambridge.
Driving Wheel
Sliding bogie axle
P=pressure.
W= Waste Water
Waste
Blake pump
to Weigh
Hydraulic Cylinder attached to one driver - Hydraulic piston attached to the other driver
A B
A is open B must be shut and v.v.
A open steam under reg. - water is valved - B valved steam from boiler for the pump.
Pump Sn Cath worked by Goldsmith valve used
P
A.B.
P cut
air vessel
Spring Valve Handle
St. Cyl.
41
Steam Water Cyl.
Steam accumulator
Watson Steam regulator at hand of engineman
Steam From Boiler
Bogie axle
Driving Wheels

Cut No. 60 shows the layout of the hydraulic arrangements by which the driving-wheels are made to adhere to the track with any degree of adhesion desired.

It is seen now that the arrangement differs in no essential particular from an ordinary locomotive, except that its grip is obtained by hydraulic power; and as there has been so much mystery associated with that, I have made a sketch showing a pair of driving-wheels coupled together by a hydraulic cylinder which receives liquor from an accumulator actuated and controlled by steam.

By a 5-way valve, the engineman may throw the hydraulic pressure to one or the other end of the hydraulic cylinder, coupling the driving-wheels, at the same time connecting the other end of it with the waste. Thus he can pull the drivers together or push them apart as he may desire. The piston in the accumulator is thrown back to its normal position by an ordinary Blake pump; or if we please, the pump fills a supply-chamber which has an air-chamber attached, without the steam-accumulator; thus we may secure the same result. This departure is a very radical one. It enables me to design the engine so that at the will of the engineman he may make its adhesion whatever he may require at the given place. And it is found by the arrangement that a very great speed can be got up in a very short distance, the engineman being capable of utilizing the full effective pressure of the steam in the cylinder; and it also enables us to build an engine with the least weight possible in its parts, while it might carry a cylinder of high dimensions. If I had made the hydraulic cylinder coupling, the driver and its attachments, a very little heavier, with a welded instead of a riveted frame for the engine, to secure the requisite strength, to pass over our abnormal tracks, we might have put in the engine we have built a

24 x 24 inch cylinder, or one of any other proportion with but a slight increase in the engine's weight; the importance of this provision is of vast moment. Our tracks are strong enough to sustain both trains and engines of greater capacity. Thus it will be seen that this railroad has been designed with a view to the future growth of traffic far beyond anything which has yet been seen. To get some idea of the appearance of the cab, its dimensions, etc., see cut No. 6, p. 19.

By an examination of the trucks upon the tracks, it will be seen that, to produce a derailment of the train, it would be necessary to derail every truck separately. (See cut No. 1.) I believe there never was developed a primary force in a railroad accident such as could do this. A train might be run off an open switch or the end of a track, but upon my switch a derailment could not well occur, without it was broken down by the grossest negligence of those in charge and then it would give notice of the fact by electrical means.

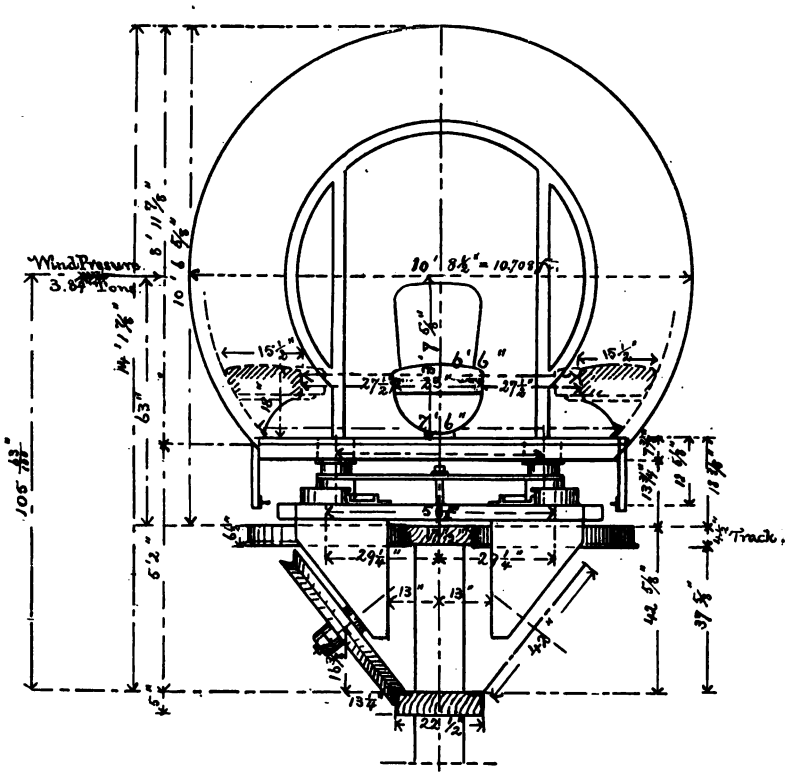
THE CAR

as exhibited in the many cuts already inserted is 51 ft. 2 in. long. It weighs 34,000 pounds with its trucks complete. It is from 8,000 to 14,000 pounds lighter than ordinary cars of its length, while its strength above that of the standard car of its size has been very much increased. It will seat thirty-three per cent. more passengers; seventy-two as the seats are now arranged, and with a change of arrangement eighty-four passengers may be seated without inconvenience, and with a little crowding, not much, 104 persons can be seated, giving

each person more than two inches more seat-room than the horsecars allow on their summer cars.

A still greater reduction of dead-weight per passenger can be made by lengthening the car, so that if a 75-foot car be built we would get something near 156 seatings and a corresponding reduction of dead-weight per passenger.

Your special attention is drawn to this car, because there



Cut No. 61.—Showing cross-section of Meigs Railway cylindrical car, its dimensions, seats, truck attachment, turn-table, and the spring-boxes attached to it, and its kingbolt. For clearness the drawbar and lower part of truck-frame straddling the lower rail are left off. (See other Cuts, Nos. 1, 2, 35, 39, 42, and 43.)

can be no doubt but that the requirements of rapid transit can only be fully met by such cars; those of small seating capacity will not give relief. My cars place the greatest number of people in the shortest space, with least weight of car per passenger, giving the greatest interval between trains, thus permitting the greatest safe speed. This, with non-interference by ice and snow, teams or other obstruction, meets the whole requirement. For comfort it has provision to let in fresh air, and a means of drawing out foul air, at the same time securing a freedom from drafts. The arrangement of the windows secures a very excellent light and freedom from draft, dust, or rain while open.

General Herman Haupt, C.E., who during the war of the Rebellion was selected by the President and War Department to be the manager and the military director of the railways of the United States of America; a writer of text-books upon bridge-building, and an engineer of lifelong experience, had occasion to report upon my system of railway. He examined my models, heard my lectures, verified the many difficult mathematical problems which had been solved by my brother, James L. Meigs, C.E., and after many weeks of patient labor, wrote a report which will sound like prophecy in the future, for in nothing was he mistaken, and from which I take his general summary.

GENERAL HERMAN HAUPT'S GENERAL SUMMARY.

In conclusion, the undersigned is of opinion —

1. That in the Meigs system of elevated railroads the centre of gravity of the moving weight is lower and the stability greater than in any system now in use.

2. There is no difficulty in setting up and supporting posts by concrete; and when planted six feet below and properly secured at the surface of the ground, their stability should be much greater than if inserted in sockets at shallower depth.

3. The truck proposed for engines and cars, which is without rods, bolts, nuts, or any loose parts, and solidly riveted, is far superior in every particular to any now in use; it should be stronger, safer, and more durable.

4. The rails of this system, presenting greater surface and more elasticity, are less liable to abrasion than the rails of ordinary roads.

5. If one or more wheels should be broken, no derailment could occur and passengers could suffer no harm.

6. If an iron rail should be removed, the trains would run almost as well without it, and the fact of such removal would not be noticed by passengers.

7. The wheels can run in a bath of oil without danger from leakage, and the lubrication would be unusually perfect.

8. The proposed system is practicable, and safer than that used in New York or elsewhere.

9. A variable and controllable adhesion is preferable to that which arises simply from dead-weight. If cylinder power can be secured for propulsion without great size and weight of boilers, the independent adhesion will give the same tractive power with less weight, and an increased bearing-surface will reduce the abrasion of rails and tires.

10. No system ever before proposed, so far as known, presents so great facilities for turning curves and angles. The sharpest curves on ordinary railroads deflect from the tangent

five degrees in one hundred feet, but a half-inch play in the Meigs truck would permit a deflection of ten degrees in ten feet, without binding; and if the curvature should be still sharper, the only effect would be to press the wheels apart, slide them upon the axles, and temporarily increase the play, but only while the pressure continued.

11. Angles even as high as ten degrees would not cause derailment of trucks nor any violent concussion at ordinary speeds. Trees that had fallen across the track would be readily pushed aside; cattle and other live-stock could never trespass upon it; other obstructions could find no lodgment; and wheeled vehicles could never be demolished nor travelers killed at road-crossings.

12. No other system proposed for elevated city railroads will cause so little obstruction to light. The obstruction will be about one fourth that opposed by the elevated railroads of New York.

13. The annoyance from noise will be reduced to a minimum, and almost neutralized.

14. A serious objection to ordinary surface railroads is the damage to property from cuts and fills, the necessity of fencing, the difficulty of providing cattle passes and road-crossings at convenient points, the wide space rendered useless for agricultural purposes, and the greatly increased travel often rendered necessary in harvesting crops; — but the Meigs system occupies no more space than a line of poles; permits live-stock or teams to cross in a field at any point; occupies no farming-land; requires no embankments, and reduces cuts, when necessary, to very narrow limits, a shallow V-shaped excavation being generally sufficient.

15. The facility for turning sharp curves and angles will permit the Meigs Road to be located on ground where an ordinary road would be impracticable, and even to follow roads and fences, if required, instead of occupying valuable lands.

16. The cost of maintenance of way, as compared with either ordinary elevated or surface roads, will be greatly reduced. There will be but one truss, instead of two, to maintain. The abrasion of rails will be greatly reduced, and consequently their durability increased; their renewal will be comparatively simple and inexpensive; the angle-iron can be turned and used until both flanges are worn out; there are no culverts to wash out nor embankments to be carried away by floods; no slides to remove nor ditches to be cleaned out; no ballast or ditching trains required; and by using preservative processes, the durability of wooden posts and stringers can be greatly extended.

Having considered and discussed the various mechanical devices submitted for examination, and attempted to answer the interrogatories propounded, this report on the same is respectfully submitted.

H. HAUPT,
Consulting Engineer.

To this summary of General Haupt, I am pleased to add: In August last I had demonstrated to the Hon. Thomas Russell, chairman of the Railroad Commissioners, who alone of the Commission could be spared from the duties of the office at the time, to visit East Cambridge, — together with his daughters, Misses Minnie and Dora, and his guests, Count J. Meuccioli, envoy from his Holiness the Pope, and bearer

of the beretta to Cardinal Gibbons, of Baltimore; Captain F. H. Garcia, government director of the Sonora Railway; General A. Ybarra; Dr. Bastillo, of Cuba, and other distinguished gentlemen, — that with a train loaded with water and passengers weighing in all seventy tons, an engine built upon my system, with controllable adhesion, with two 12-inch cylinders could pull itself and train up and over a 50-foot half-circle or horseshoe curve followed by a very short level track, thence over a 50-foot curve on a 345-foot grade followed by a tangent grade of the same nature, joined by a 172.5-foot grade by knuckle or abrupt change of grade, this high grade immediately preceded by a series of abrupt changes of grade by dished angles every 11 feet, from level to 60-foot to 120-foot to 240-foot to 300-foot to 345-foot grade, which would have destroyed any other engine and would have ditched the train, greatly to the delight of the Judge, the greatest railroad expert of the age. And yet we did not conclude to finish our experiments, because we wished

TO EXHAUST THE SUBJECT BEYOND CAVIL,

and present the railway in the best condition possible when we did open it to the public.

No locomotive on earth could have done what was then accomplished. Neither the grade nor the curve was possible to another style, and when I ran the train up that grade at varying speeds, even as high as thirty miles an hour, it caused Judge Russell, who had ridden over it more than once, with all of his knowledge of railways, to write me such complimentary words as to class my railway with Niagara as a wonder, and to ask for a day when he might bring his honored guests to see it.

To these endorsements, dear to me (now still dearer), I am pleased also to add that of General George Stark, of Nashua, New Hampshire, whose great depot for the Lowell Road, of which he was manager, stands a monument to his sagacity, foresight, and ability. He was selected to examine my railway by the honorable Board of Railroad Commissioners of the State of Massachusetts, in accordance with the charter granted me to build a railway from Bowdoin Square in Boston to Cambridge and return. He based his report approving the system, first upon a masterly review of it, — the result of nearly three months of examination of the models, plans, figures, — and by tests of the full-sized railway itself. Upon these conclusions and examinations he made a report, expressing his own views, and finished his report with a summary to meet the exact requirements of the law calling for it. General Stark was selected to make this examination by the Commissioners because he was a non-resident and unbiased, and because he was known to be a high-strung and honorable man, incapable of forming an opinion without reasons, and good reasons, and because he is so well known in connection with great and successful engineering achievements.

From the EIGHTEENTH ANNUAL REPORT of the Board of Railroad Commissioners, p. 35. Public Document No. 14. January, 1887.

Action as to the Meigs Elevated Railway Company.

By chapter 87, Acts of 1884. It is provided that "No location [of the Meigs Elevated Railway] for tracks shall

be petitioned for in the city of Boston, until at least one mile of the road has been built and operated, nor until the safety and strength of the structure and the rolling-stock and motive-power shall have been examined and approved by the Board of Railroad Commissioners, or by a competent engineer to be appointed by them, and to be paid by said corporation a price fixed by said Board."

After examining the structure, rolling-stock, and motive-power of the Meigs Elevated Railway, as they existed October 27, 1886, the Board appointed General George Stark, of New Hampshire, a competent and independent civil engineer, to act upon the approval of the structure, rolling-stock, and motive-power. His report is given in full (Appendix I), and the Commissioners approve it and will in due time take formal action upon the points submitted to the Board.

APPENDIX I.

GENERAL STARK'S REPORT.

To the Board of Railroad Commissioners of the State of Massachusetts: —

GENTLEMEN, — I had the honor to receive from you, on the 27th of October last, an appointment as engineer, under the provisions of section 4, chapter 87, of the Acts of 1884, for the purpose of "examining the safety and strength of the structure of the Meigs Elevated Railway, so called, in Cambridge, and the rolling-stock and motive-power used thereon, and of approving or disapproving the same."

In pursuance of this appointment, I have since devoted a very considerable portion of my time and attention to the

required examination, and beg leave now to submit this, my report: —

The experimental section of Meigs Elevated Railway, which has been constructed at East Cambridge, is located on grounds formerly occupied by the Bay State Glass Company, and extends over Bridge Street to grounds of J. P. Squire & Co.

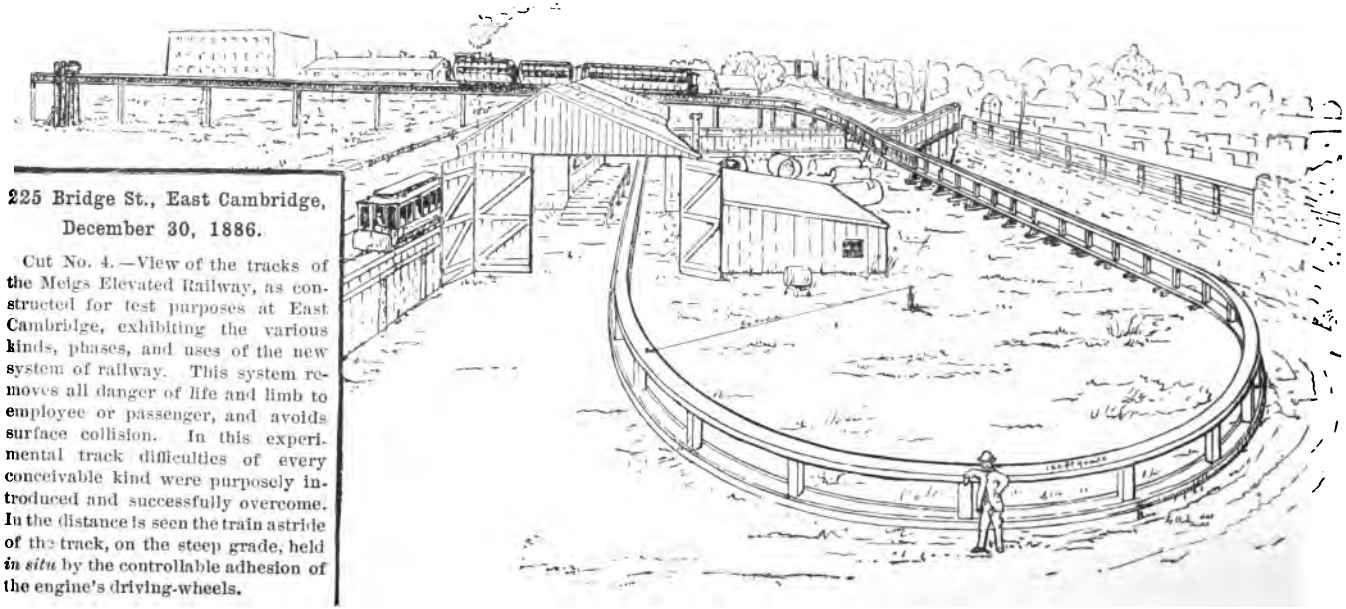
The structure has been erected wholly on made land, upon what was once the bed of Miller's River, and the mud underneath this made land is soft and deep. A rod of round iron, five eighths of an inch in diameter, was easily forced down, near the structure, by one man, in my presence, its entire length, twelve feet, without striking hard bottom.

The difficulty of building a secure single-post structure on this foundation has, of course, been much greater than it would have been on ordinary solid land.

In addition to this natural difficulty, Captain Meigs has purposely introduced artificial obstacles in his track, for the purpose of showing that he can run his trains around curves of less radius, and on grades of greater elevation, than are now practicable on ordinary steam motor railways, and can safely pass horizontal or vertical angles in the track of very considerable deflection. One of his curves makes an entire semi-circle, with a 50-foot radius on a grade of 120 feet to the mile, and another turns nearly a quarter-circle, with a radius of 50 feet, on a grade of 345 feet to the mile.

The construction of the track is simple, and the question of its strength and safety is easily determined.

The entire structure consists of a single line of girders supported on a single line of posts; the two rails on which



225 Bridge St., East Cambridge, December 30, 1886.

Cut No. 4.—View of the tracks of the Meigs Elevated Railway, as constructed for test purposes at East Cambridge, exhibiting the various kinds, phases, and uses of the new system of railway. This system removes all danger of life and limb to employee or passenger, and avoids surface collision. In this experimental track difficulties of every conceivable kind were purposely introduced and successfully overcome. In the distance is seen the train astride of the track, on the steep grade, held *in situ* by the controllable adhesion of the engine's driving-wheels.

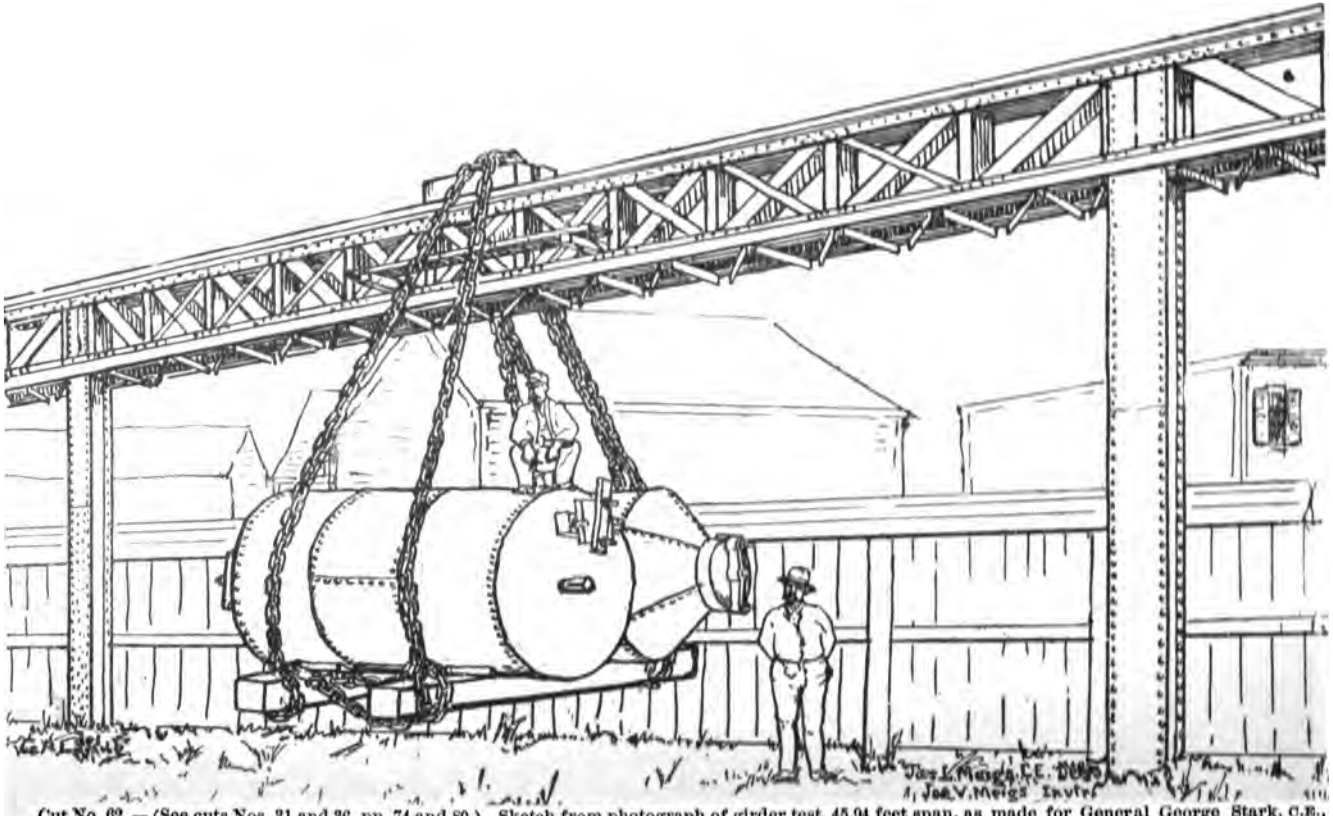
the bearing-wheels supporting the load run, being placed on the upper outside corners of the lower boom of the girder, and the two rails that resist the pressure of the horizontal driving and guiding wheels being placed on the outer sides of the upper boom of the girder.

THE PROBLEMS TO BE SOLVED

are, first, as to the strength of girder for sustaining a vertical load represented by the fixed weight of the girder and the moving weight of the train passing over it, and for resisting the horizontal strains and twists that may come either from the grip of the driving-wheels, or the momentum of the train, or the action of wind; and, second, as to the strength of the posts for sustaining the weight of girders and trains, and their stability and power of resistance against side-pressure, caused by momentum or wind blowing upon the side of the train.

The railway company has submitted to my examination extensive and thorough computations, made by engineers in their employ, to show the force of these various strains, and the amount and form and quality of material required in the girders and posts, to safely resist and bear the loads and strains to which they are or may be subjected.

These computations show that the structure, as built, is, theoretically, of ample strength and stiffness, under all circumstances, to safely carry the train; and the numerous trips that I have myself made over it, with the locomotive and cars, practically verify these theoretical calculations.



Cut No. 62. — (See cuts Nos. 31 and 36, pp. 74 and 80.) Sketch from photograph of girder test, 45.94 feet span, as made for General George Stark, C.E., for the honorable Railroad Commissioners, as required by the Massachusetts Legislature. Load, thirty tons and a fraction. Deflection, $\frac{3}{10}$ of an inch. Girder returning to normal condition after removal of load.

THE WAY LOADED.

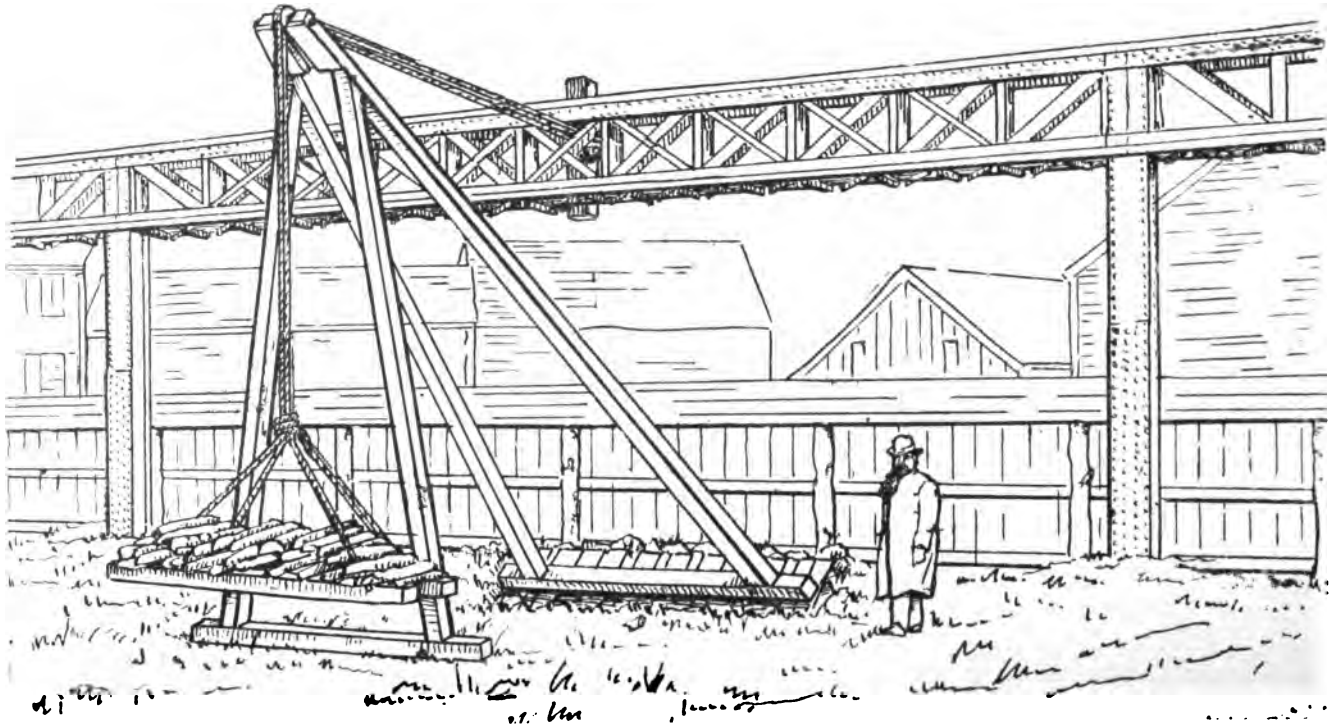
But for the purpose of more tangible verification, I caused one of the longer girders to be loaded, in my presence, with a known weight, of nearly double the amount that could be brought upon it by the train, and noted myself the results by gauges arranged to show the deflection. The girder experimented upon is about 46 feet long, and its lower boom is about 18 feet above the surface of the ground.

Two large iron cylinders (rendering-tanks), laid on cross-timbers, were suspended under the exact middle of the girder by means of a heavy chain passing over the upper boom. The tanks were then filled with water, making an aggregate weight of water, tanks, chain, and timber, of 60,187 pounds, or about 30 net tons, equal to a distributed weight of 60 tons upon the girder — a load greatly in excess of any that could ever be put upon it by the train. The depression of the girder at its centre under this load was seven sixteenths of an inch; and on removing the load, the girder sprang back to its original position.

To test practically THE POWER OF THE GIRDER TO RESIST LATERAL STRAINS ARISING FROM PRESSURE OF WIND AND UNBALANCED LOADS, computations have been made, based upon the force of a hurricane blowing 110 miles an hour, squarely against the side of the train, when the load is out of balance by passengers being at the same time all on the leeward side of the car. And the side-pressure on a girder, arising from these

EXTREME CONDITIONS,

is computed to be equal to about $4\frac{42}{100}$ tons. By means of a cable attached to the centre of a girder and passing



Cut No. 63. — Sketch of photograph of test of girder, 45.94 feet span, as made for General Stark, for the report of the honorable Railroad Commissioners; required by the Massachusetts Legislature. The same as if a wind were blowing at 33 lbs. per square foot against the walls of the car. The girder deflected ⅜ of an inch; posts deflected ⅛ inch: returning upon removal of load to normal position. This would be a wind effect of a hurricane blowing 110 miles an hour.

horizontally over a loose pulley in the top of a shear, and suspending vertically a platform loaded with pig-iron, I applied a force of $5\frac{29}{100}$ tons, to pull the girder sideways; being an excess of 20 per cent. over the computed extreme force of combined hurricane and unbalanced load. The side deflection of the girder at its middle, caused by this pressure of $5\frac{29}{100}$ tons, was three eighths of an inch. This pressure caused the posts supporting the girder under test to bend at their tops one half of an inch. On removing the weight the girder and posts sprang back to their original positions.

As the iron posts are of good design and well built, and securely fixed in place by foundations of timber and concrete, and have stood the pressure and strain of the train passing over them at frequent intervals for some months, I consider them satisfactory, and that

NO FURTHER TEST OF THEIR STRENGTH IS NECESSARY.

The method of filling them with concrete, so arranged as to mainly take the weight, instead of leaving it to be supported by the iron shell, is especially commendable.

The wooden posts now in use on the low part of the structure answer very well for experimental purposes; but in a line intended for city traffic I should advise that iron posts, filled with concrete, be adopted in all cases.

The structure of this experimental piece of railway, as now submitted to my examination, is, in my opinion, safe and sufficiently strong, except in the plate angle iron rails on the lower boom of the girder which have proved too light, and are about to be replaced with heavier ones.[1]

It contains, however, objectionable curves and grades and angles,

PURPOSELY PLACED THERE FOR EXTREME TESTS,

to show what obstacles may be overcome, if necessity compel them to be encountered, and to find out what changes may be desirable in the proportions of the machinery. In my opinion, these extreme features should be eliminated and, wherever possible, kept out from any line intended for business purposes.

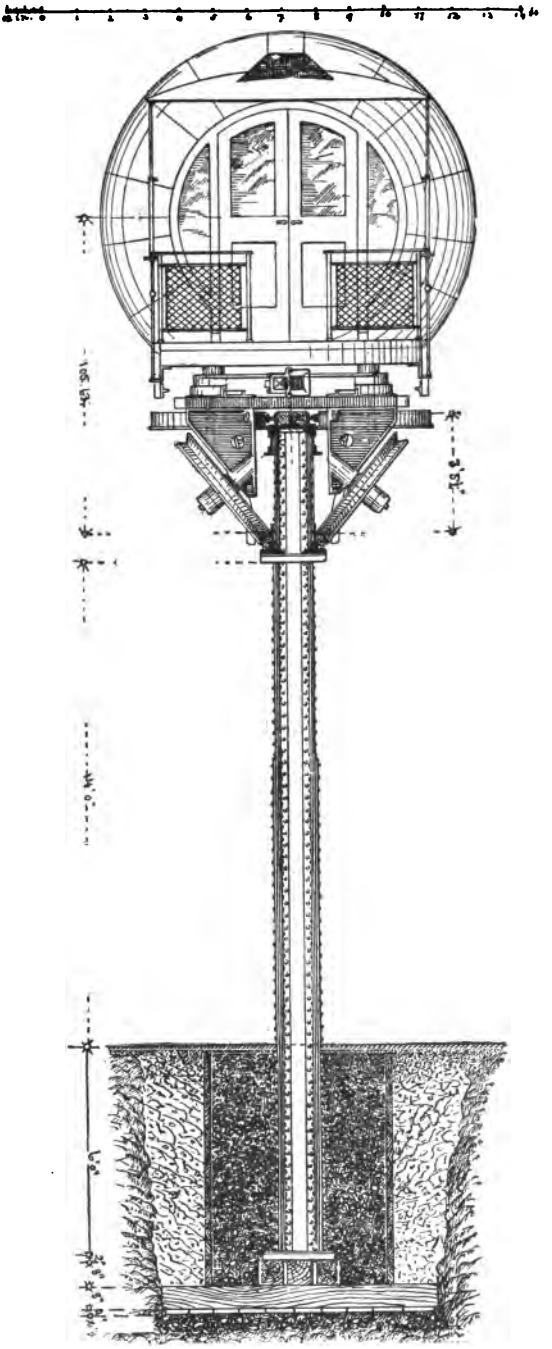
THE MOTIVE-POWER AND ROLLING-STOCK

submitted to my examination consists of a locomotive, weighing about 30 tons; a tender, weighing about 14 tons; and a passenger-car, weighing about 17 tons; making up a train of about 61 tons aggregate weight when empty.

Excepting the distinctive running-gear, or trucks, of this railway system, the general features of the motive-power and rolling-stock correspond to, or are supposed improvements upon, the locomotives and cars of ordinary steam-railways.

A cylindrical shape has been adopted for all the equipment, for which shape peculiar advantages are claimed as to

[1] General Stark, it seems, did not understand that the wooden way was not submitted for test for use in the city. It was alone upon this part of our tracks that the light and seamy iron, all that we could then purchase, proved too light. J. V. M.



Cut No. 2. — The above cut is an end representation of the car upon the track — its trucks, the post, and its setting; showing the trucks astride of the track 48 inches.

safety, convenience, and economy, and particularly as to offering less resistant surface to the wind.

THE CAR IS MORE ELEGANT AND COMMODIOUS INTERNALLY THAN ORDINARY CARS, AND BEING LARGELY BUILT OF METAL INSTEAD OF WOOD, IS SAFER AS REGARDS FIRE, OR AS REGARDS SPLINTERS IN CASE OF ACCIDENT. The turn-table arrangement of the trucks also seems stronger and safer than the trucks now in common use.

The leading features of the system centre in the trucks. They are constructed to straddle the girder, so that if all the bearing-wheels were knocked off, the fall of the truck would not be over two or three inches on the top boom of the girder, on which it would slide or rest.

The wheels that bear the weight, instead of being placed in the ordinary upright position, are fixed at an angle of about 45 degrees from the vertical plane; the bearing-face of the wheels being grooved to fit down upon the angle iron supporting-rail on the upper corners of the lower boom of the track girder, so as to bear both downward and inward on the rail. Each wheel has its own independent axle securely fixed in the iron jaw of the truck at right angles to the plane of the wheel. *By this arrangment, the axle strains and the slipping of wheels on curves, so troublesome in wheels and axles of the ordinary construction, are wholly avoided; and it becomes possible to use sharper curves in the track than have ever before been practicable.* Each truck has also two horizontal guide-wheels, bearing against the rails on the sides of the upper boom of the track girder, *to prevent the truck from swaying.*

As the sustaining-rails of the track on the lower boom of

the girder are but 22½ inches gauge, and the wheels stand sloping outward from these rails, on an angle of about 45 degrees, the first appearance of the rolling-stock, to a casual observer, is one of extreme instability. But upon investigation and practical test this appearance is found to be deceptive. Careful mathematical and mechanical analysis of the arrangement of the wheels and axles shows the plan to be theoretically correct, AND THAT, AS A MATTER OF FACT, THIS ARRANGEMENT OF TRUCKS, UPON PROPERLY CONSTRUCTED GIRDERS, IS MORE STABLE AND MORE SAFE THAN THE TRUCKS OF ORDINARY ROLLING-STOCK UPON THE ORDINARY RAILROAD TRACKS.

For the purpose of testing the safety of these trucks in the event of accident, I caused one wheel to be removed from a truck under the car, so that the car would be in the condition of losing a wheel by breakage while in motion. The train was then run over the track with one wheel gone. There was no perceptible tipping of the truck on account of the absence of this wheel, and no apparent tendency to derailment. The absence of the wheel would not be noticeable to passengers in the car.

I also caused a section of the supporting-rail and timber of one side of a lower boom to be cut away and removed, leaving an open gap of about six feet in the track. The car was then pushed over this gap and, of course, became derailed; but it only dropped about two inches, and slid along on the upper boom as securely as if on its wheels. The centre of gravity being but little above the boom on which

the car rested, the side-wheels and truck-jaws held the car effectually in horizontal position with very little strain, apparently; a derailed car, on this system, could not tip over, which cannot be said of ordinary railroad cars on the ordinary railroad tracks.

The locomotive has some minor novelties of construction besides the truck arrangement above alluded to, not necessary here to describe; but its main features are, the horizontal driving-wheels which pull the train by side-pressure on the rails of the upper boom of the girder, and the hydraulic attachment by which the pressure or adhesion of these driving-wheels upon the rails is created, maintained, and regulated at will by the engine-driver.

This motor has accomplished some remarkable feats. It draws itself and the attached train, with apparent ease and at great speed, around sharper curves and up heavier grades than the ordinary locomotive can pass. But being the first of the kind ever built, of full size, and having been from the outset put at work on a track purposely planned to bring out in this experimental stage any existing weakness of design (thorough trial on unusual grades and curves and angles, requiring machinery of great perfection and power to overcome these extraordinary obstacles), it has, as might be expected, proved weak in some of its minor proportions, and there has been more or less breakage in the strained parts. All the defects thus far developed seem, however, to be

SUSCEPTIBLE OF EASY REMEDY,[1]

and no doubt, in future construction, the proportions of the parts will be greatly improved.

[1] These remedies have been made.—J. V. M.

With so radical a departure from the ordinary mode of applying locomotive power, it is only to be expected that perfect proportions will develop slowly and out of the results of extended use or practical experiments. This is but the usual rule applying to all inventions.

The result of my investigations may be summed up as follows: —

THE EXPERIMENTAL SECTION OF THE MEIGS ELEVATED RAILWAY NOW IN USE AT EAST CAMBRIDGE IS, IN MY OPINION, ABUNDANTLY STRONG FOR ITS INTENDED USE AS AN ELEVATED RAILWAY TRACK, AND IS SAFE FOR THE PASSAGE OF ITS EQUIPMENT.

The rolling-stock and motive-power used thereon are also strong and safe for their intended use, no breakage having occurred, or being likely to occur, that could imperil personal safety, either in or out of the cars.

A line of railway, properly constructed on this principle, for passenger or freight traffic, and equipped with such rolling-stock and motive-power, on this principle, as the Meigs Company is now prepared to perfect and build, would, in my opinion, be at least as strong and safe for any kind of traffic as the ordinary surface or elevated steam-railways now in common use.[1]

In view, however, of the imperative necessity for the best class of design and construction in everything appertaining to an elevated railway, I think it would be wise for the State of Massachusetts, through its Board of Railroad Commissioners, or otherwise, to regulate the strength and design of

[1] These words meet the exact requirements of the law. General Stark's views are seen above. J. V. M.

all materials used in construction, and the weight and design of equipment to be run, etc., as is done by New York, through its "Rapid Transit Commission," for elevated railroads in that State.

I attach to this report some sketches, kindly furnished by Captain Meigs, showing a perspective and a sectional view of his track and equipment, and the methods used by me for applying the weight and pressure tests to the girders and posts.

Respectfully, your obedient servant,

GEORGE STARK,
Civil Engineer.

December 23, 1886.[1]

[1] The capitals and italics are mine. — J. V. M.

Here I add a chapter of horrors, in parallelism, taken from the morning papers of one day only. It will explain itself. But to those who will not read understandingly I will say, that upon the Meigs Elevated Road with its trucks astride of its tracks 48 inches in depth, instead of one inch as in the elevated and surface roads of 4 ft. 8½ in. gauge, there will never be a loss of life by such accidents.

A PARALLELISM.

A SINGLE DAY'S ACCIDENTS WHICH THE MEIGS SYSTEM WOULD HAVE PREVENTED.

The 4 ft. 8½ in. Gauged Railway.	The Meigs Railway.
"DEATH ON THE RAIL."	
Lovers on the Eve of Marriage Run Over and Killed.	
While Joseph O'Razz and Lizzie Sontra, a young Hungarian couple who were soon to be married, were walking on the Consolidated Railroad track near South Norwalk, this evening, they were struck by an east-bound train and almost instantly killed. The bodies were terribly mangled.	The lovers would have lived. This class of accidents will not occur upon it.
An Unknown Man Killed on the Boston & Lowell.	
As the early Montreal express on the Boston & Lowell Railroad was passing the Prison Point crossing at East Cambridge, yesterday, an unknown man stepped upon the track and was instantly killed. The head was severed from the body and beaten into a shapeless mass.	This horror could not have happened.
Two Men Killed.	
Two cars of a passenger-train on the Rocky Mountain division of the Northern Pacific Railway became detached, ran three miles down a heavy grade, jumped the track, and were smashed. The express messenger, named McNally, and an unknown passenger were killed. Twenty passengers were badly shaken up.	These occurrences would not have taken place. No derailment would have occurred or passengers have been injured.

The 4 ft. 8½ in. Gauged Railway.

Engineer and Fireman Killed.

A freight-train on the Memphis & Charleston road was ditched near Tuscumbia last night. Engineer Mahony and his fireman were killed and the conductor and a section boss were wounded. — *The Lowell Morning Times, December* 27, 1886.

The Meigs Railway.

Ditching of train cannot occur, and these lives would have been saved.

KNOCKED INTO SPLINTERS.

A Street-car Run Into by a Train — Four Persons Seriously Injured.

Chicago, Ill., Dec. 27, 1886. — A street-car containing fifteen persons was run into this morning by the St. Louis express at the O'Neill Street crossing on the Chicago & Alton Railroad and knocked into splinters. The passengers were thrown in every direction, but only four were seriously injured. — *Boston Herald, December* 27, 1886.

Lives cannot be imperiled in this manner. My road cannot be run on the surface in this way to imperil life.

DRIVING OVER THE TRACK.

Dr. Latimer's Buggy Struck by the Train — Physician and Wife Hurled Headlong from their Carriage.

Dr. J. A. Latimer and wife, of East Cambridge, received serious injuries by being struck by a train on the Fitchburg Railroad, at Union Square crossing, at 1 o'clock yesterday afternoon. They left their residence on Otis Street about 11 o'clock, and visited one of the physician's patients in Somerville. About 12.15 they started to return

The 4 ft. 8½ in. Gauged Railway.

home, and as they were driving through Newton Street a freight-train of forty cars had just passed the station on its way to Boston.

The gate-tender was expecting the 12.45 express from Boston, but, not hearing the train annunciator ring, concluded it was some distance away and raised the gates. The annunciators had, however, rung, but the noise made by the passing freight-train prevented the gateman from hearing them.

As soon as the gates were opened, a heavily loaded Charles River horsecar started to cross in order to continue its journey along Webster Avenue towards Union Square. At the same time Dr. Latimer and his wife started to drive across to continue along Newton Street. All this time the express-train was rapidly approaching the crossing, but unknown to any one in that vicinity. Dr. Latimer had driven partly across the track when he was stopped by the horsecar. He then drove around it, and had just reached the other side when he saw the approaching express-train.

He whipped up his horse, but it was too late, for the train struck the rear part of the carriage, demolishing it, and throwing out the physician and his wife.

Mrs. Latimer was picked up unconscious and remained in that state for over four hours. She was injured about the head, and it is feared will not recover. Dr. Latimer had two ribs on the left side and his right wrist fractured,

The Meigs Railway.

There would have been no gate-tender. He could not have made a mistake.

A freight-train could not have delayed traffic and endangered life.

The heavily loaded horsecar could not have been imperiled. Dr. Latimer could not have driven on the track.

The 4 ft. 8½ in. Gauged Railway.

and his spine was severely injured. Had the car been delayed a second longer, it would have been struck by the train. As it was, it just grazed the rear dasher. — *Boston Globe*, *December* 27, 1886.

The Meigs Railway.

What suffering would have been saved!

After more than thirty years of experiment, study, labor, expenditure of money, and of difficulties, obstructions, grievous hardships, and hope so long deferred that it indeed made the heart sick, I have been enabled to proportion, determine, and prove the strength of parts, and practically demonstrate the principles involved in my system of railway, and therefore deduce from these demonstrations

MY SUMMARY.

SAFETY TO LIFE AND LIMB OF PASSENGER IS ABSOLUTE, BECAUSE:

1. Ditching[1] of a whole train is impossible. It would necessitate the absolute destruction of the way, which will be guarded against by a telegraphic system, so that a destroyed track would not be attempted by the engine and train. It would necessitate the destruction of every truck under the whole train — an impossibility.

2. Ditching of a single car is impossible. The drawbar would tie the car to its fellow were the truck disabled; but

[1] The word ditching is used because the mere straining of the wheels off the track, were that possible, would not be such a derailment as would throw the train into the ditch.

detachment of a truck is not possible. It is a thousand times stronger than is that of the present system.

3. Ditching at curve and

4. Ditching of the engine is impossible. We have tried our engine weighing thirty tons pushed up by its train, by running it at very high speed, thirty-three miles an hour, over a piece of track left purposely weak at the sharp 50-foot curve on the high 345-foot grade; that is, the rails were cut at opposite sides of the curve, the wood being the only dependence; and we ran no risk. Ditching certainly would have occurred, had it been possible.

5. Broken rails would be unnoticeable to passenger. We have proved it over and over again.

6. Broken wheels would not injure life or limb. We have tried to break a wheel by obstructions bolted to the way, but did not succeed; so a wheel was removed, and train run without it.

7. Broken axle would not be noticeable, and would be a matter of no serious import.

8. Broken rods and chains cannot possibly produce accident and loss of life or limb.

9. Derailment of the lower or bearing wheels by a strained truck, were that possible, could not produce serious results. We have tried it by removing the lower rail and running over the place.

10. Broken upper boom of girder would not derail train. We have tried it.

11. Washout by rainstorm not possible; hence not dangerous.

12. Land-slide not possible, hence no dangers from.

13. Culverts — there will be none, hence no dangers from.

14. Cross-ties to rot out — none; no dangers from.

15. Cross-ties to be tamped — none; no dangers from.

16. Ditches to be kept up — none; no dangers from.

17. Washouts by high water — impossible; no dangers from. We have built a stable way in a tide laden bog.

18. Accidents from snow and ice are eliminated, the trains having been run on tracks as badly iced as they ever will be.

19. Dangers from collision to life and limb are removed because of decreased weight of train per passenger; because of an opportunity for a better telegraphic warning system, not liable to disarrangement by the elements, or other cause; because the engineman can use his drivers as brakes to any degree he may please; because provision has been made to take up the greater part of the shock of collision; because the colliding trains will not be derailed; because colliding trains cannot be telescoped but must receive such shock in the longitudinal direction of the train and way; because the floors of the train and its bracework to sustain such shocks have been vastly increased in strength over the old style; because the trucks are tied down to the tracks by the flanges of the balancing-wheels; because the seats are securely fastened through the floor of cars and upholstered at salient points; because the cars are upholstered on their walls; because the cars cannot be splintered: and because the cars cannot burn from themselves, being metal-lined throughout.

20. Collisions from surface causes are entirely removed. It will be impossible to run over obstructions or be derailed

by obstructions or by careless persons, or by cattle; thus the safety of life and limb and the payment of damage removed; therefore higher profits and cheaper fares and freights.

21. Switches cannot be left open, and enginemen cannot go unwarned of broken switches; such are the provisions by well-known and tried mechanical means.

22. Passengers passing between cars of the train cannot be thrown off the train or between cars.

23. THERE IS GREATER SAFETY TO LIFE AND LIMB TO PERSONS NOT PASSENGERS,

because careless, imbecile, deaf, abstracted, or preoccupied persons cannot walk in front of the engine or upon the way.

Persons riding in teams cannot drive across the tracks in front of trains.

Whole scores of people riding in horsecars cannot have their lives endangered by being driven in front of train or engine.

There are no grade crossings of common roads or railways, neither of surface railways nor those of the same kind, to imperil life and limb.

This railway cannot run on the surface of streets and does not imperil life and limb, and therefore it is absurd to call it, by legislative enactment, or otherwise, an

ADDITIONAL SERVITUDE

to the streets more than a telegraph-pole would be.

24. THERE IS AN ABSOLUTE IMMUNITY FROM THE COMMON CAUSES OF LOSS OF LIFE OR LIMB TO EMPLOYEE.

Depotmen cannot be killed by stepping in front of trains.

Switchmen cannot be run over or neglect the switch.

Workmen working about the track cannot get by accident in front of trains.

Trainmen cannot be killed coupling cars, nor at bridges, nor by falling between cars.

Enginemen running special fast trains do not increase their risks.

Enginemen will not be scalded in case of collision.

Enginemen will not be killed by broken parts of their engines.

Enginemen will not be killed or maimed by breakage of axle.

Enginemen need not use excessive boiler-pressure.

25. Comfort to those not passengers, to the families of people engaged in the railway service, is inestimably increased, and the peace of mind of those whose friends must of necessity travel will be assured. The farmer need not fear the destruction of his lawn or farm by reason of the location of the road through it. Persons living near the line will not be annoyed by dust and smoke, oil, water, noise, nor by the falling of detached pieces: these difficulties are all removed. The way in, and the passage of the trains through, a street will not offer hindrance nor obstruction to light and air, nor fill the air with dust and smoke. The passage of the railway through the street will give great facility with absolute safety of reaching given points at less cost of time and money. Rapid transit increases values at centre and at suburb and everywhere along its line by reason of the commonsense rule of greater facility of communication and accessibility.

26. Passenger fares and freight charges may be less by

reason of the removal of the causes of cost of operating. By reason of the removal of the costs of maintenance of way. By reason of the absence of the costs of damage for maiming and killing passengers and those not passengers. and destroying property. By reason of less cost of equipment. By reason of the absence of friction from vibrations and high centres of gravity. By reason of loose wheels, reducing frictions. By reason of a small consumption of coal and oil. By reason of less cost of right of way.

COMFORT TO PASSENGER IS ASSURED,

as I have proved practically at East Cambridge: —

Because of safety from all known causes of accident.

Because a primary accident like a breakage of rail or wheel never produces secondary results, and could not be known by the passenger.

Because of reduced costs to passenger.

Because of nicer, cleaner, more roomy cars.

Because of freedom from dust from engine or earth.

Because the passengers are elevated above the filth and bad odors of the street.

Because of freedom from foul air.

Because of freedom from drafts of cold air.

Because of riding over larger wheels which roll fewer times in a given distance.

Because of riding over wheels which are concentric with axle, which have true bearings, running steadier, without shifting, receiving all loads by right-angle thrusts of axle.

Because of riding over a track on which rail joints are not perceptible.

Because of gliding over a continuous way.

Because of the absence of cross-ties.

Because of riding in cars which are nearly free from noise.

Because steadier pulled by the movement of the engine.

Because the trucks are provided with balancing-wheels, the springs of which take up all side momentums and vibrations at curve or change of direction.

Because the wheels of the truck are arranged to neutralize the pressures and shocks induced by each other.

Because there is no fear of being burned, the cars being unburnable from fires originating within the cars.

Because the cars have but one half the wind-strain.

Because the passenger need not suffocate during a rain-storm.

Because of a greater number of cubic feet of better air.

Because the way is strong enough and the cars are attached to the rail securely enough to prevent derailment or ditching by even a hurricane or collision.

Because of better designed seats.

Because he is sure of no detention.

THE SYSTEM FURNISHES A MEANS OF RAPID TRANSIT

because by it we seat the greatest number of people in a shorter length of train than by any other system, the ratios for length of train being 1.02 for surface roads, .94 for New York Elevated, and .49 for my system. It admits of the use of powerful engines. It admits of speed, with freedom from delay from any cause. This is rapid transit.

GREAT SPEED IS ATTAINABLE.

The system of controllable adhesion admits of the use of large drivers and cylinders, with correspondingly slow piston and high train speeds; a perfect utilization of the power of the steam in the cylinder being possible, on this account, and on account of the peculiar combinations I have made, my engine has drawn with 60 POUNDS OF STEAM, on a fair day, over a rusty, smutty, dirty track, itself, its tender and car, in all when fully loaded about 71 tons of weight. Starting on the level (see cut No. 7, p. 20) in the shed, running twelve feet on the level, thence over the abrupt junction of the level with the 50-foot curve upon a 120-foot grade and around the horseshoe or half-circle curve made by the track, a distance of 165 feet, GAINING SPEED, thence over another abrupt break of grade, the junction of the curve with the level straight line, thence 209 feet, thence over the most remarkable and trying track to a rolling-stock and engine ever built, consisting of six abrupt breaks of grade every eleven feet from the level to a 60-foot grade, to 120, to 240, to 300, to 345-foot, thence up the 50-FOOT CURVE ON A 345-FOOT GRADE, making nearly a quarter turn in 55 feet, thence up the tangent grade of 345-foot to the mile, making 136 feet, thence over a knuckle, purposely made in the track, the abrupt junction of the 345-foot grade with that of 172.5 feet (see cut No. 8, p. 21), thence up this grade making an abrupt junction with the level way 14 feet 8 inches above Bridge Street, East Cambridge, to the bunter some distance beyond, traversing the grand curve made up purposely of track so joined as to make an angular way, the angles now laid horizontally

instead of vertically, making nearly abrupt changes of direction. (See cut No. 9, p. 23.)

The engine does this work on very bad tracks indeed, in the very worst weather.

In all ordinary weather, when we so chose to do, it can do the work upon 80 pounds of steam; our gauges being set at 145 pounds.

Master Machinist Mr. D. B. H. Bartlett ran the engine and train over this way, starting from the sheds, gaining 33 miles an hour by the time he reached the second curve and high grade (see cut No. 7, p. 20), — 50-foot radius 345-foot grade, — passing it in absolute safety and without fear to those riding. Mr. Samuel A. Fish ran the nose of my engine, on a fair day, the 17th of February, 1887, for the aldermen of Boston, to the foot of the 345-foot grade and there halted; then opening the throttle, the engine pulled itself, tender, and car up the tremendous grade and curve, gaining speed in so doing. This has often been repeated, since we put in the maximum strength of parts, instead of those of minimum strength which were used in determining the proportions of parts; thus it is proved that with the excessive safety of the track, as approved, and of the truck system astride of the track four feet, and violently tested, that all breakage of rail or other parts does not produce secondary or other accidents but remains as primary accidents; that by this system any speed which may be desirable can be attained, uninfluenced by storm, snow, or flood. In other words, we have demonstrated and secured official approval of my claims to have designed a *safe* railway, permitting greatly increased speed, with increase of

power without increasing COSTS either for way or maintenance.

I am, very respectfully yours,

JOE V. MEIGS.

NOTE.

AT four A.M. on the morning of February 4, 1887, an incendiary fire burned the greater part of the shed containing my engine, tender, and car. But for the police and the fire departments my whole train would have been destroyed by the intensity of the fire built about it. As it was, "the most magnificent car ever built" was melted down by the furnace into which it was thrust; its metal plates were melted down and the little wood and upholstering burned out. This is the last of a series of attempts of like nature to hinder the progress of my efforts. First, out of pure malice, my models were mutilated and broken, at the State House. Then the building, No. 89 Court Street, where my lecture-room and models were placed, was set on fire; they broke into a vacant room immediately beneath, pulling off the mopboard and firing the partition. They have mutilated the car at East Cambridge by cutting, and other petty annoyances. These criminal acts are merely futile, and grieve me, but do not hinder the enterprise in the least. J. V. M.

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